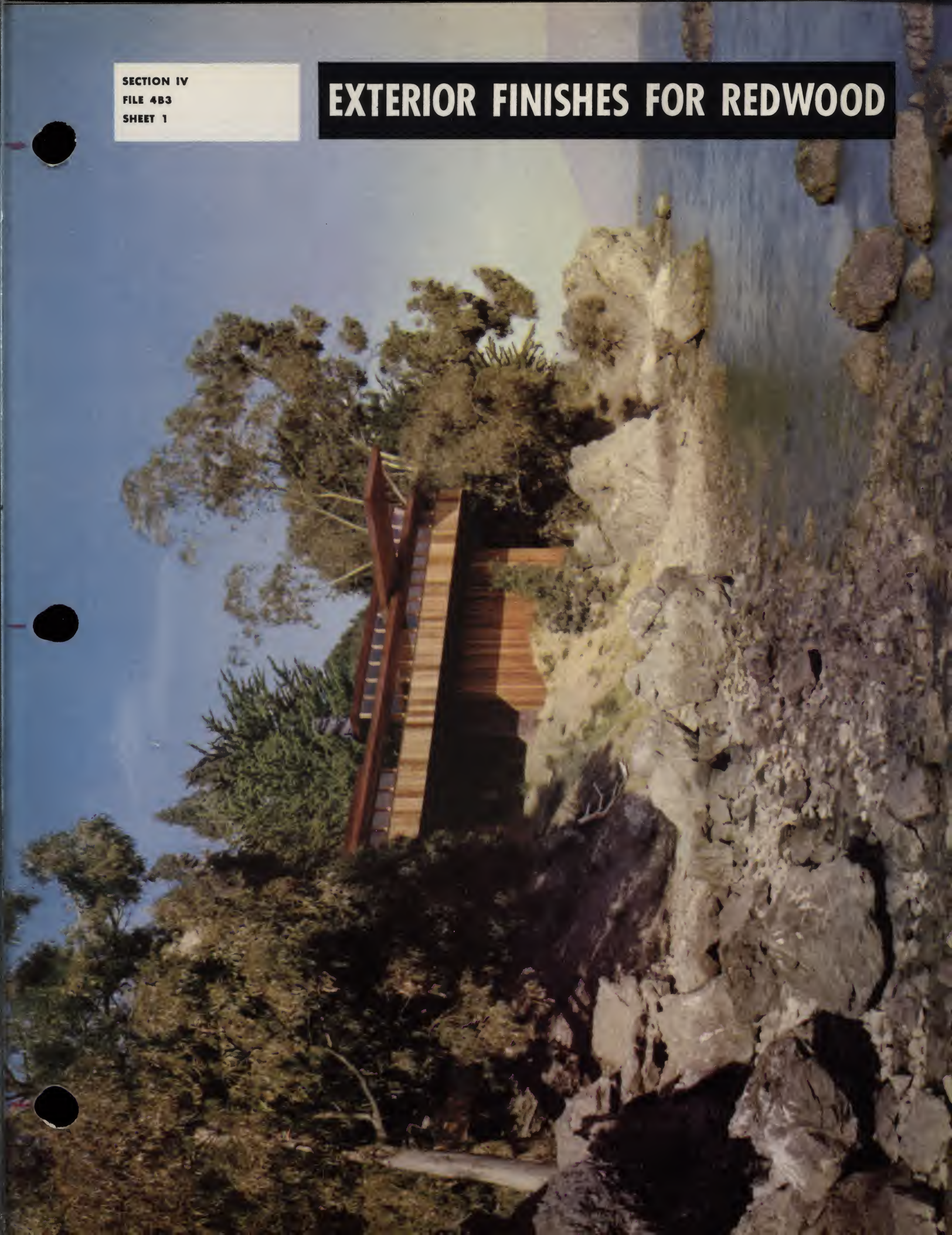


SECTION IV
FILE 483
SHEET 1

EXTERIOR FINISHES FOR REDWOOD



The purpose of finishing exterior redwood is to produce a certain effect in harmony with the completed structure and the landscape. Heartwood grades of redwood need no protective finish. They are frequently left with no surface treatment at all, for they are very durable and will weather gracefully through many decades of service.

If a finish is desired, it may be used with assurance that, applied to redwood, it will give its best service since tests have shown that redwood holds all finishes extremely well.¹ Finishes will last up to 35 percent longer on redwood than on some other woods commonly used for sidewalls. The open cellular structure and low shrinkage factor of redwood help to maintain a good bond between the wood and finish film. Also, there are no oils or resins in redwood to weaken the film.

The wide variety of exterior finishes available ranges from opaque paints, which provide a full film protection over the wood, to bleaches with no film. All of the finishes will suffer some discoloration and gradual breakdown in time. This does not mean deterioration of the wood surface underneath. The different types give varying lengths of service but, regardless of the type selected, refinishing will be necessary periodically to retain the desired appearance.

PAINT

Characteristics: Generally slightly glossy when first applied, but gloss is reduced during weathering. Completely hides grain and natural color of the wood. Most durable exterior finish. No special preparation of old surface required before refinishing. **Initial Application:** One prime coat and two finish coats. **Refinish:** When paint wears thin so the shadow of wood is beginning to show through in spots.

NATURAL EFFECTS

Many owners prefer to preserve as far as possible the natural color and grain of the wood. There is no way of keeping any wood very long with exactly the color and natural sheen which it had when first manufactured, but many of the finishes now on the market approach this condition as closely as possible. For this purpose, stains, stain-and-clear combinations, or clear finishes are used even though they are not as durable as paint. In order to determine which of these more natural finishes perform satisfactorily on redwood, the California Redwood Association conducts extensive tests of these treatments. The tests are made in several locations representative of the varying climates found in the United States.

A list of natural finish systems, which these tests have shown to possess better than average service life, is given in "Supplement to Redwood Data Sheet 4B3-1." This supplement is revised from time to time as additional information is developed.

Weathered Redwood

Some architects and home owners prefer to allow exterior redwood to weather naturally. When handled in this manner, redwood gradually darkens and, in areas where it is exposed to moisture and sunlight, eventually bleaches to a soft gray. This produces rustic effects which are ideal in certain settings and, of course, reduces expense and main-

tenance to a minimum. The gradual graying results from the action of both sunlight and moisture. It may be hastened by occasionally flushing down the sidewall with a garden hose. Redwood which has been allowed to weather may be painted or stained at any time without difficulty. However, if a clear treatment is desired, it is necessary to remove the weathered surface by a light sanding before the clear finish is applied.

Moisture Repellents and Penetrating Sealers

Characteristics: Generally without gloss and produce little color change when first applied. They delay and modify the effects of natural weathering, but do not prevent it. No special preparation of the surface necessary prior to re-finishing. **Initial Application:** Generally two coats.

BLEACHES

Characteristics: Produce a uniformly gray weathered appearance. Very durable. No surface preparation before reapplication. **Initial Application:** Two coats. **Refinish:** When the wood begins to darken and a lighter effect is desired.

Bleaching is a chemical process to hasten the characteristic color change of weathered redwood, furnishing a more even appearance than occurs with natural weathering. It eliminates the darkening that often precedes the ultimate light gray appearance. It is desirable to spray the finished surfaces with water occasionally to assist the bleaching action, as this depends on both moisture and sunlight. Flushing the surface occasionally with water will also eliminate streaky areas and keep it clean.

PIGMENTED STAINS

Characteristics: Flat effect. Comparatively inexpensive. Easy to apply; easy to refinish because the old film tends to weather down evenly. These finishes have an even longer life when used on rough-sawn wood surfaces. Available also in various other pigments as well as the "natural" redwood colors. **Initial Application:** Generally two coats. **Refinish:** When necessary to restore original color.

If rainstorms result in a streaky appearance, the siding should be hosed down with water from top to bottom. This flushing action will restore the uniform appearance of the finish.

STAIN-AND-CLEAR COMBINATIONS

Characteristics: Gloss effect. Somewhat more durable than the clear finishes used alone. **Initial Application:** Generally consists of the stain prime coat with two clear finish coats. It is recommended that the prime coat and the clear finish be from the same manufacturer to insure compatibility. **Refinish:** When the film begins to lose its integrity and shows fine weathering cracks. Inspect periodically and refinish at the first sign of film failure.

CLEAR FINISHES

Characteristics: Durable clear finishes tend to be glossy, though the sheen is gradually reduced by weathering. Those listed in the supplement have been selected to eliminate excessive cracking and peeling. They can be refinished after a minimum of sanding as surface preparation. Many of the varnish systems on the market give poor service and fail by rupture and peeling. **Initial Application:** One prime coat and two finish coats are usually recommended. **Refinish:** Same as for stain-and-clear combinations.

¹Forest Products Laboratory, U. S. Department of Agriculture, Madison, Wisconsin.

HOW TO PREVENT DIFFICULTIES

The five most likely causes of exterior finish failure are:

Moisture Within Lumber—Lumber should be dry. For kiln-dried quality, specify "CRA—Certified Dry." Keep lumber dry and clean at the job. Proper construction (flashing, vapor barrier, air vents) eliminates access of moisture behind finish film, which can cause blistering, especially in full-film paints and clear finishes.

Use of Materials Unsited for Exteriors—Several types of finish materials have certain advantages when used in the proper place, but are not suited for complete exterior finish treatments on redwood. Among these are:

Unprocessed oils (linseed, soya, tung, fish, etc.)

Interior finish products.

Failure to Follow Manufacturer's Directions—The instructions of the finish manufacturer, printed on the label, should be closely followed. Thin the finish only according to these directions. If more than one type of finish is to be used, such as a stain with a clear, be sure the manufacturer recommends the use of the two together.

Mixing Incompatible Materials—Many finish failures result from mixing finish materials which are not compatible, or from applying a finish incompatible with the remains of the old finish already on the structure. Generally any pigmented stain can be applied over another pigmented stain after the latter has weathered at least a year. However, in refinishing with a different type of finish, it is safest to get the recommendation of the finish manufacturer.

Failure to Refinish When Needed—No specific rules can be given as to the time refinishing should be done. Some exposures are more severe than others, and some types of finishes have a longer life than others. Appearance of the surface, as noted under each type of finish, is the best guide.

CAUSES OF DISCOLORATION

Dirt: Dark, blotchy areas on the finish may mean that dirt and soot have discolored it. Painted surfaces can be

cleaned with scrub brush and solution of mild detergent. On natural finishes, substitute a cloth or soft-bristled brush for the scrub brush.

Mildew: More likely, the dark areas are caused by mildew, evidenced when the blotchy discoloration is within the film itself. First scrub the surface clean with a scouring type cleanser, and then rinse with antiseptic solution of household disinfectant of the hypochlorite type, and water. After disinfectant has dried, refinish with mildew-resistant finish. (See mildew note in supplement.)

APPLYING THE FINISH

The possibility of subsequent problems due to moisture is greatly reduced if the siding is dipped or brushed so that it is back-, face-, and end-primed before it is nailed in place. Unless the finish system has a special primer included, prime with same material as used for finish coat, thinning to manufacturer's directions. Since the end grain of wood is particularly absorbent, a special effort should be made to prime the ends of all lumber which is exposed to the weather so that moisture is sealed out.

When a natural finish is to be used, shield the wood from prolonged exposure to sunlight until the finish is applied. Color changes can occur in the unfinished wood in a short time. If nails are counter-sunk, use a non-oily wood filler to avoid stains.

A cool, windless day is the most favorable for finish application. Extreme heat may result in improper drying, and wind can cause dust accumulation on the finish. Avoid painting while wood is damp following a storm. Wood surfaces should be dry to the touch.

Apply according to manufacturer's directions, and use recommended number of coats (see supplement.) Before applying finish coats, wipe accumulated dust off the preceding undercoat, and touch up uneven areas. Natural finishes, as well as paints, can usually be sprayed as well as brushed.

For additional information on finishes and finish maintenance, write California Redwood Association, 576 Sacramento Street, San Francisco 11, California.
Cover Illustration: Residence designed by Jack Hillmer.
Photograph © Roy Flamm.

USE GUIDE FOR REDWOOD FINISHES

Shows types of finishes most commonly used for various applications.

USES	FINISHES							
	OPAQUE		BLEACH	STAIN	CLEAR FINISH OVER STAIN		CLEAR FINISH ALONE	
	Paint	Enamel			Oil	Varnish	Oil	Varnish
SIDING Surfaced	X		X	X	X	X	X	X
Rough	X		X	X				
FENCES Surfaced	X		X	X	X	X	X	X
Rough	X		X	X				
DOORS, SILLS & THRESHOLDS		X				X		X
OUTDOOR FURNITURE		X		X		X		X
RETAINING WALLS			X	X				

BLEACHES

Bleaches achieve, chemically, the ultimate driftwood gray of weathered redwood in a shorter time than is required for this change to occur naturally. Texture and grain character of the wood are revealed. Trouble-free and very little maintenance.



PIGMENTED STAINS

These flat stains add color to the wood surface, producing a dull effect without completely concealing the grain figure. These are easy to apply and refinish, and comparatively inexpensive. Available in a range of colors.



STAIN-AND-CLEAR COMBINATIONS

Similar to the clears except for thin stain undercoat which provides uniform color without obscuring grain lines and natural characteristics of the wood. (All photographs shown above are greatly reduced.)

CLEAR FINISHES

The clear finishes show grain pattern to full effect. The most durable are initially very glossy, but gloss is reduced gradually by weathering. Supplement lists those which weather without excessive scaling.

CALIFORNIA **Redwood** ASSOCIATION

576 SACRAMENTO STREET • SAN FRANCISCO 11, CALIFORNIA

EXTERIOR FINISHES

(Supplement to Redwood Data Sheet 4B3-1)

The following listed finish systems* are recommended by their manufacturers for outdoor use on redwood. Listings are based on minimum durability tests of panels prepared by the finish manufacturers for the California Redwood Association. 215 systems have been tested.

The blackening of many finishes is due to mildew. These finish systems have not been tested for their ability to resist mildew. In areas where mildew is likely to be a problem, we suggest that you ask your dealer about the advisability of adding a mildewcide to the finishes which you have under consideration.

BLEACHES

<i>Manufacturer</i>	<i>Finish System</i>
Samuel Cabot, Inc. 141 Milk Street Boston 9, Massachusetts	2 Coats Bleaching Oil #241 (redwood test panels, treated with this finish, became a light greyish color where exposed to direct sunlight. The same color change took place more slowly where the panels were exposed to indirect light)
Olympic Stained Products Co. 1118 Leary Way Seattle 7, Washington	1 Coat Bleachtox—This product was tested on rough sawn lumber; we do not suggest its use on surfaced lumber. (redwood test panels, treated with this finish, were bleached effectively where exposed to direct sunlight. They bleached more slowly where exposed to indirect light)

PIGMENTED STAINS, FLAT EFFECT

Samuel Cabot, Inc. 141 Milk Street Boston 9, Massachusetts	2 Coats #247 Bark Brown (redwood test panels, treated with this finish, became darker where exposed to direct sunlight and slightly lighter where exposed to indirect light)
Samuel Cabot, Inc. 141 Milk Street Boston 9, Massachusetts	2 Coats #3625 Sequoia Red** (redwood test panels, treated with this finish, became lighter where exposed to direct sunlight and were unchanged where exposed to indirect light)
W. P. Fuller & Co. 301 Mission Street San Francisco 19, California	2 Coats #3576 Redwood Tone Stain (redwood test panels, treated with this finish, became slightly darker where exposed to direct sunlight and did not change appreciably where exposed to indirect light)
Linseed Oil Products Co. 1107 So. Fremont Avenue Alhambra, California	2 Coats Redwood Color Preservative #4 (redwood test panels, treated with this finish, became lighter where exposed to direct sunlight and slightly darker where exposed to indirect light)
Monsanto Chemical Company 911 Western Avenue Seattle 4, Washington	2 Coats Redwood Rez (redwood test panels, treated with this finish, became slightly darker where exposed to direct sunlight and very slightly darker where exposed to indirect light)
Olympic Stained Products Co. 1118 Leary Way Seattle 7, Washington	2 Coats California Rustic** (redwood test panels, treated with this finish, became slightly lighter where exposed to direct sunlight and showed no appreciable color change where exposed to indirect light)
Rudd Paint & Varnish Co. 1608 15th Avenue West Seattle, Washington	2 Coats Nat-U-Seal (redwood test panels, treated with this finish, became darker where exposed to direct sunlight and were unchanged where exposed to indirect light)
Wesco Waterpaints, Inc. Fifth & Grayson Berkeley, California	2 Coats Redwood Resin Finish** (redwood test panels, treated with this finish, became lighter where exposed to direct sunlight and slightly darker where exposed to indirect light)

STAIN-AND-CLEAR COMBINATIONS, GLOSS EFFECT

Linseed Oil Products Co. 1107 So. Fremont Avenue Alhambra, California	1 Coat Liquid Raw-Hide Redwood Stain and Sealer #3
	2 Coats Liquid Raw-Hide Redwood Finish-Clear (redwood test panels, treated with this finish, became much lighter where exposed to direct sunlight and slightly darker where exposed to indirect light)

Perfection Paint Products Co.
1272 86th Avenue
Oakland 3, California

Sillers Paint & Varnish Co.
Terminal Annex 2081
Los Angeles 54, California

Sillers Paint & Varnish Co.
Terminal Annex 2081
Los Angeles 54, California

Western Wood Preserving Co.
3432 East 15th Street
Los Angeles 23, California

Bishop-Conklin Division
Devoe & Raynolds Company, Inc.
3950 Medford Street
Los Angeles 63, California

Garland Company
3748 East 91st Street
Cleveland 5, Ohio

Meta-Kote Corp.
P. O. Box 113, Station D
Toledo 8, Ohio

Perfection Paint Products Co.
1272 86th Avenue
Oakland 3, California

Western Wood Preserving Co.
3432 East 15th Street
Los Angeles 23, California

Since the evaluation of these finishes has been based on resistance to weathering rather than on color and effect, we suggest that you ask your dealer to show you samples of these finish systems, as applied to redwood, so that you may judge their appearance.

If the finish is to be applied over an existing finish, you should so inform your dealer in order that he may properly advise you. We also suggest that a test be made on a small, inconspicuous area to determine whether the old and new finishes are compatible and whether the desired effect is attained.

Manufacturer

Beverly Manufacturing Co.
9118 South Main Street
Los Angeles, California

Boyle-Midway, Inc.
4820 East 50th Street
Vernon, California

Webb Products Co.
G & Columbia Streets
San Bernardino, California

3 Coats Perfection Redwood Spar
(redwood test panels, treated with this finish, became very slightly lighter where exposed to direct sunlight and very slightly darker where exposed to indirect light)

1 Coat Sequoia Redwood Finish #15P13

2 Coats Sequoia Redwood Finish #1V61
(redwood test panels, treated with this finish, became very slightly lighter where exposed to direct sunlight and did not change color appreciably where exposed to indirect light)

3 Coats Sequoia Redwood Finish #15P13

(redwood test panels, treated with this finish, became slightly lighter where exposed to direct sunlight and slightly darker where exposed to indirect light)

1 Coat Golden State Redwood Stain

2 Coats Golden State Redwood Finishing Oil

(redwood test panels, treated with this finish, changed color only slightly where exposed to direct sunlight and became slightly darker where exposed to indirect light)

CLEAR, GLOSS EFFECT

3 Coats Redwood Clear Hi-Gloss

(redwood test panels, treated with this finish, became very slightly lighter where exposed to direct sunlight; no information was developed on the effect of indirect light)

3 Coats Supernite Varnish #810

(redwood test panels, treated with this finish, became very slightly lighter where exposed to direct sunlight and very slightly darker where exposed to indirect light)

1 Coat Par Spar Redwood Varnish Primer X3747

2 Coats Par Spar Redwood Varnish Finish X3748

(redwood test panels, treated with this finish, became very slightly lighter where exposed to direct sunlight and slightly darker where exposed to indirect light)

3 Coats Perfection Wood Spar

(redwood test panels, treated with this finish, became darker where exposed to direct sunlight and where exposed to indirect light)

3 Coats Golden State Redwood Finishing Oil

(redwood test panels, treated with this finish, became lighter where exposed to direct sunlight and darker where exposed to indirect light)

If a finish or finish system is not named on this list, it may only indicate that it has not been tested. Absence from the list is not necessarily to be interpreted as failure. In some cases, finishes which have failed the tests may, under certain conditions of exposure, give satisfactory service. In other cases, an individual user may feel that the appearance of a less durable finish more than compensates him for more frequent refinishing.

It is recommended that nail holes in redwood be filled with a non-oily filler if a natural finish is contemplated. Some wood fillers* of this type are:

Wood Filler

Famowood, Redwood Color

Plastic Wood

(may be tinted with a dry pigment such as Burnt Sienna)

Duratite Wood Dough, Light Mahogany Color

*Listed alphabetically by manufacturer within each class.

**Heavily pigmented, obscure the grain when first applied.

MAINTENANCE OF EXTERIOR FINISHES



The superior paint retention characteristics of redwood are major factors in providing assurance of long life for an exterior finish application, but to no greater degree than the attention given to its proper care and maintenance.

NEW WORK

A satisfactory finish job results when a high quality finish is properly applied to a good surface. On new redwood it is necessary only to select a good finish of the type and color which will produce the desired effect, then to apply it to a clean surface according to the manufacturer's instructions. It is most important to specify CRA-Certified Dry redwood for any finish job, and to insist upon proper construction, to prevent premature finish failure.

No finish can be protected from normal weathering by sunlight and moisture on the surface, but the siding must be protected from dampness during construction, and from moisture vapor from inside the house. Abnormal moisture conditions under the finish film may result in the discolorations characterizing premature failure of the most durable finish. Construction practices influencing finish performance by preventing abnormal moisture conditions which must be guarded against, are discussed in Data Sheet 3A4-1, Redwood Siding: Application.

The ability of a finish to resist the normal weathering of sunlight (most serious on clear finishes) and moisture on the

surface, is the measure of its durability. Data Sheet 4B3-1, Exterior Finishes for Redwood, gives information about the various types of finishes and lists by brand the finish systems which have met minimum durability requirements.

REFINISHING

In the life of any structure, periodic refinishing will be necessary. The length of time between finishings in normal practice will vary with climate, exposure, and type and quality of finish originally applied. No definite time can be stipulated because of these variables, but the appearance of the surface should be sufficient indication of the need for refinishing.

Opaque white and lightly tinted paints described as "self-cleaning" are generally dependable. They gradually wear away and eventually expose the wood if left long enough. The best time to refinish is when the paint has worn to the extent that the wood appears as a shadow beneath it. A light sanding or brushing with a scrub brush will usually prepare this surface for refinishing.

Pigmented stains present few problems in refinishing. They generally fail by erosion, indicated by a gradual fading of the stain. Refinishing should be done before the color fades completely. A light sanding or brushing is the only preparation necessary.

Clear finishes require more careful attention because, if they are allowed to weather to a point where the wood

is exposed, some discoloration will result. Also, these finishes do not wear uniformly and if they are permitted to crack and peel, total removal of the finish may be necessary before a new one is applied. Refinish at first sign of film failure, usually indicated by a slight bleaching of the wood, or at the first sign of small breaks or cracks in the surface. Sand lightly before the new finish is applied.

METHODS OF REMOVING FINISHES

When it is necessary to remove an old finish, either because it has deteriorated or because a different effect is desired, certain methods are recommended.

Deteriorated Finishes

If many coats of opaque or clear oils and varnishes have been applied without correct preparation, and cracking and peeling have resulted, the old material should be completely removed and the refinishing done on a fresh wood surface.

Sanding or wire brushing will give good results in areas where the old finish has deteriorated, and is effective in removing stain-type finishes when a different effect is desired.

Removing a Good Finish

When the finish to be removed is still in good condition, either burning or the use of a paint and varnish remover will save labor. Burning should be done only by an expert, and it should not be done where a clear finish is subsequently to be applied.

Types of Removers

Paint and varnish removers fall into three general classifications: (1) those using organic solvents, which may be flushed off with water; (2) those using organic solvents, which require surface scraping; and (3) those in the form of a powder which is dissolved in water before application. Easiest to use but most expensive are removers of the first type. Removers of the third type are relatively inexpensive, but require more

labor, and may be ineffective on some finishes. All paint and varnish removers should be checked for effectiveness, and should be tested on a piece of new, clean redwood to be sure they will not cause discolorations. This is especially important when they are to be followed by a natural finish.

Steel wool should not be used on exterior redwood because particles break off and embed in the wood where, on contact with moisture, they cause dark stains.

RESTORING ORIGINAL COLOR

After the old finish has been removed, and prior to the application of a natural finish, it may be desirable to lighten the color of the wood. This is done by bleaching with a solution composed of four ounces of oxalic acid crystals per gallon of water.

This solution should be swabbed over the wood with a soft cloth or brush, and allowed to dry. The surface should then be rinsed with clear water. To prevent streaking, apply the solution to an entire board, or area, at one time. When discoloration is severe, several applications may be necessary.

This solution will also remove water marks from redwood, and will reduce dark stains resulting from contact of redwood with iron, such as plain iron nails. *Caution:* oxalic acid is poisonous and should be used with care.

DISCOLORATION OF THE FINISH

The conditions that result in discoloration of a finish are varied, and their causes often mistakenly identified.

Surface Accumulations

Dirt and dust accumulations on the surface are a common cause of discoloration. This condition may be easily corrected on any type of finish by washing with a solution of mild detergent, then rinsing.

Mildew growth frequently is mistaken for dirt or extractive bleeding. It is much more prevalent than generally realized, and every precaution should be employed to guard against it. Mildew appears as dark spots with lighter-colored areas spreading below. Spores from the original mildew colony wash down and multiply, forming fan-shaped gray areas. When mildew infection is severe, the result may be a uniform gray discoloration.

Mildew grows on and in the finish film, rather than on the wood, consequently any finish material used should be protected against mildew. If this protection has not been provided by the manufacturer, the finish may be made resistant to mildew attack by adding one ounce of an organic-mercury mildewcide to each gallon of finish.

Menace of Moisture

Premature failure of a good quality, properly applied finish may be attributed almost invariably to moisture under the finish film. The three most prevalent sources are moisture from beneath the house, from within the house, and from the outside. The condition may be due to moisture vapor moving from the inside to the outside when a vapor barrier is not present; to wind-driven rain gaining access to the sidewall, or to inadequate ventilation, particularly in sub-floor areas. The source of the moisture should be determined and corrected, and adequate ventilation provided, to protect the finish and prevent sidewall deterioration.

In an older structure, where a vapor barrier has not been provided, a coat of aluminum paint, applied on interior walls before the decorative coat is added, will serve as an effective vapor barrier.

Methods of combatting moisture in a new structure are covered in Data Sheet 3A4-1, Redwood Siding: Application.

Film separation is a typical result of the presence of moisture in wood siding. Moisture under a paint film may destroy the adhesion without producing noticeable blisters. Such effect does not become visible until the film, made brittle by weathering, eventually cracks and peels. However, when the adhesion of a varnish film is similarly destroyed, the layer of air between the film and the wood shows up as a whitening or cloudy effect, and the varnish, instead of moisture, is blamed. The penetrating opaque finishes are not subject to whitening from loss of adhesion since they are not in the form of films on the surface of the wood.

Bleeding, or migration of extractives, occurs in redwood only when an unsatisfactory moisture condition exists in the siding. Such a condition may result from excessive moisture which was in the siding when applied, and may correct itself when the siding dries out; or from moisture which gained access to the sidewall due to poor construction practices. Moisture tends to bring the water soluble extractives in redwood to the surface in the form of dark spots or streaks. These follow the grain of the wood and may be more pronounced near the ends of the boards. When these stains are fresh they may be removed by washing with water. Stubborn stains may be reduced by the application of the previously mentioned oxalic acid solution.

Redwood extractives have reacted unfavorably with several special paints, causing discoloration but not necessarily bleeding.

Nail stains are the unsightly result of fastening exterior redwood with common iron nails. The stains can be reduced by first countersinking the nails, filling the nail holes with a non-oily type filler, then applying oxalic acid bleach. Following this, a film-forming finish should be applied to avoid recurrence of the nail staining.

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REDWOOD INTERIORS SPECIFICATIONS

CHARACTERISTICS

In addition to the decorative value of its grain, texture, and color, California redwood is unexcelled by any other commercial species in the "stay put" and low shrinkage factors which are absolute essentials to satisfactory paneling installations. This unusual resistance to change in shape, either from shrinking or swelling, and the easy workability of redwood, insure tight fitting joints and preclude warping and cracking.

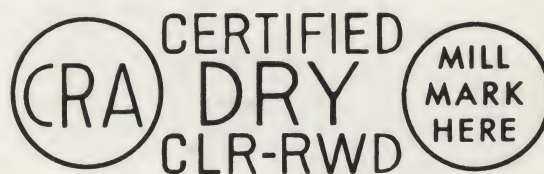
Also of practical importance is the superior capacity of redwood to take all types of finishes and hold them well. Its high insulation value is important in reducing both heating and cooling costs.

SPECIFICATION DATA

Normally the moisture content reached by interior paneling is much lower than for exterior siding, and specifiers should be particularly assured that properly kiln dried lumber goes into the paneling. Specify **CRA-CERTIFIED DRY** redwood in order to get redwood which is milled, dried and machined to the exacting standards of the California Redwood Association.

Following are the grades of redwood especially adaptable to interior usage:

Clear All Heart. The finest quality redwood finish, free of imperfections on the face. Color: The reddish hue of the heartwood throughout. Includes both vertical grain and flat grain.



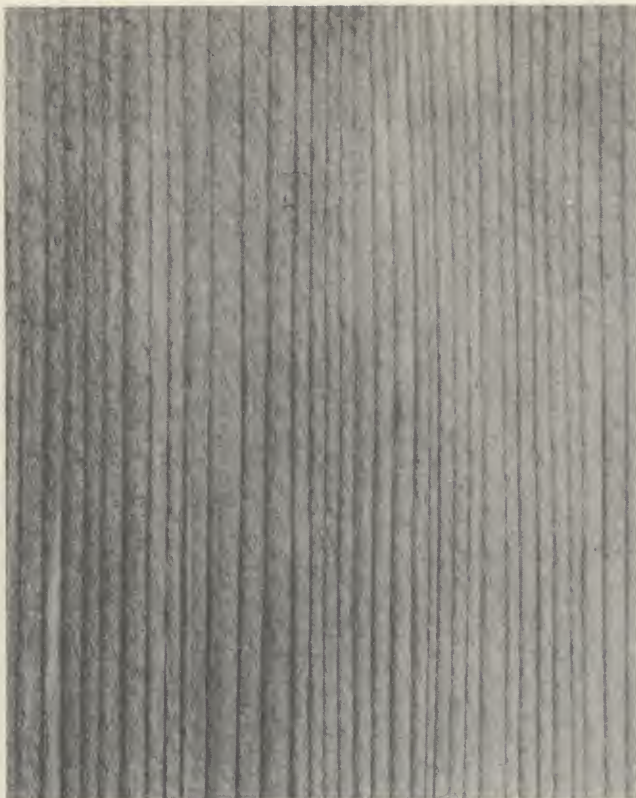
"A" Grade. High quality similar to the above. Color: The heartwood hue plus some irregular bands of cream-colored



alburnum (sapwood). Includes both vertical grain and flat grain.



Sewall Smith, A. I. A., Architect



VERTICAL GRAIN CLEAR ALL HEART



FLAT GRAIN CLEAR ALL HEART

EFFECTS

A wide variety of effects may be obtained with panels in either of these grades. The differences in grain pattern, the contrasting colors of heartwood and alburnum (sapwood), and the surface texture are all subject to individual emphasis and may be covered in the specifications. The characteristic small birdseye markings, which appear at random on some pieces, afford additional visual difference.

Grain. Discriminating use of the principal grain differences will afford a broad range in distinctive pattern effects.

Vertical Grain: These pieces have a velvety richness and relatively uniform grain line developed through centuries of

even growth rate. Grain configuration is restrained, relatively symmetrical.

Flat Grain: Greater decorative emphasis can be achieved through selection of flat grain pieces, which contain the lavish figures and grain patterns resulting from this cut of the log.

Heartwood: Heartwood boards show a reddish cinnamon hue with a range into darker and lighter colors. The mellow depth of tone results from the penetration of the color extractive throughout the cells of the wood. Specify the Clear All Heart grade.

Alburnum (sapwood): A bolder, and perfectly harmonious color effect is achieved through selection of lumber containing the irregular cream-colored strips of alburnum—the new



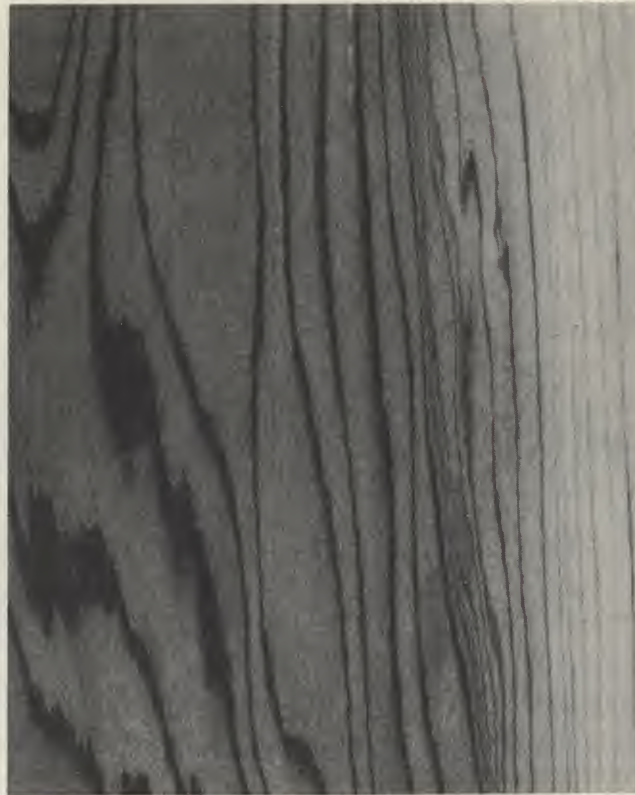
RESIDENCE, La Jolla, California. Flat grain "A" Grade board on board. Surfaced on the face, rough on edges. Russell Forester, designer.



DOCTOR'S OFFICE, Chicago. Flat grain Clear All Heart. Perkins and Will, architects. Photo: Hedrich-Blessing



VERTICAL GRAIN "A" GRADE



FLAT GRAIN "A" GRADE

wood of the tree which has not yet received its reddish colored impregnation. This companionship of the heartwood and sapwood colors is obtained by specifying "A" Grade, and is particularly striking in the flat grained pieces.

An especially pleasing and natural transition of color from the cream to the various values of red can be obtained with a little discrimination in selection and application of the "A" Grade pieces. If the pieces are laid up so that the alburnum edges are adjacent and the heartwood edges are adjacent, the color transition will be along the naturally irregular growth rings of the wood rather than along the straight joint lines of each board.

Aside from the natural variation listed above, a wide range of hues can be obtained with the various pigmented stains and glazes.

Texture. The smooth surface of planed panels and the rougher texture of the resawn face each has its place in modern architecture.

Surfaced: Unless otherwise specified the panels will be surfaced. Planing emphasizes the grain figure and color.

Rough: A very soft, pleasing texture results from exposing the sawn face. Rough lumber, as it comes from the sawmill, is too rough for use as paneling. The rough face for paneling is produced on a resaw, a finer, smoother cutting saw. Specify "Resawn face."



RESIDENCE, San Rafael, California. Accent area of "A" Grade paneling. Fred Langhorst, A.I.A., architect. Photo: Roger Sturtevant.



RESIDENCE, Downers Grove, Illinois. Redwood panels with resawn face. Schwelkher and Elting, architects. Photo: Hedrich-Blessing.



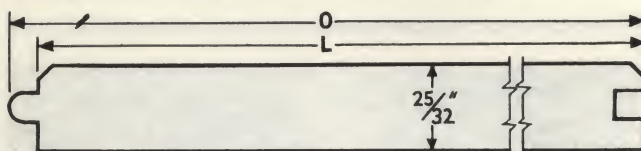
RESIDENCE, San Francisco. Eldridge Spencer, F.A.I.A., architect.
Photo: Pirkle Jones.

PATTERNS

Tongue and groove or shiplap patterns, or board and batten, are adaptable for paneling and are readily available in face widths up to twelve inches.

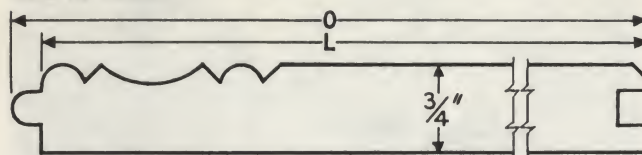
Board and Batten. Special interior effects are sometimes achieved with board and batten, reversed batten, and board on board. Board widths are available generally up to twelve inches, and standard battens are nominal $\frac{1}{2}$ " x 3" ($\frac{1}{32}$ " x 2 $\frac{1}{2}$ " surfaced). Boards of standard width and thickness are also used for battens if a heavier shadow or wider batten is desired.

Tongue and Groove. The following pattern variations of width and edge are standard in tongue and groove joint. (N=nominal size. O=overall actual width. L=laid-up, or exposed, face width. All measurements given in inches.)



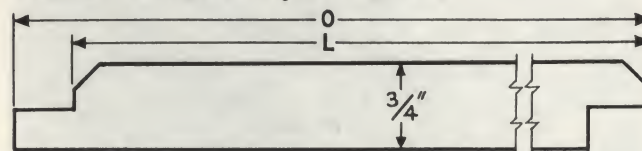
Pattern No.	N	O	L	Edge
132	1x4	3 $\frac{1}{2}$	3 $\frac{1}{4}$	Square
133	1x6	5 $\frac{1}{2}$	5 $\frac{1}{4}$	Square
132EE	1x4	3 $\frac{1}{2}$	3 $\frac{1}{4}$	Eased
133EE	1x6	5 $\frac{1}{2}$	5 $\frac{1}{4}$	Eased
207	1x4	3 $\frac{1}{2}$	3 $\frac{1}{4}$	$\frac{3}{32}$ -V
208	1x6	5 $\frac{1}{2}$	5 $\frac{1}{4}$	$\frac{3}{32}$ -V
209	1x4	3 $\frac{1}{2}$	3 $\frac{1}{4}$	$\frac{1}{4}$ -V
211	1x6	5 $\frac{1}{2}$	5 $\frac{1}{4}$	$\frac{1}{4}$ -V
212	1x8	7 $\frac{1}{2}$	7 $\frac{1}{4}$	$\frac{1}{4}$ -V
213	1x10	9 $\frac{1}{2}$	9 $\frac{1}{4}$	$\frac{1}{4}$ -V

Tongue and groove patterns also include molded variations as below:



Pattern No.	N	O	L	Edge
516	1x6	5 $\frac{1}{4}$	5	V & Mold
517	1x8	7 $\frac{1}{4}$	7	V & Mold
518	1x10	9 $\frac{1}{4}$	9	V & Mold
519	1x12	11 $\frac{1}{4}$	11	V & Mold

Shiplap. The following pattern variations of width and edge are standard in shiplap joint. (N=nominal size. O=overall actual width. L=laid-up, or exposed, face width. All measurements given in inches.)

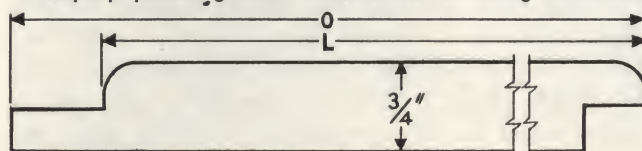


Pattern No.	N	O	L	Edge
260†	1x4	3 $\frac{1}{2}$	3	Square
261†	1x6	5 $\frac{1}{2}$	5	Square
262†	1x8	7 $\frac{1}{2}$	7	Square
263†	1x10	9 $\frac{1}{2}$	9	Square
264†	1x12	11 $\frac{1}{2}$	11	Square
290*	$\frac{5}{8}$ x6	5 $\frac{1}{2}$	5	$\frac{7}{32}$ -V
291*	$\frac{5}{8}$ x8	7 $\frac{1}{2}$	7	$\frac{7}{32}$ -V
292	1x4	3 $\frac{1}{2}$	3	$\frac{1}{4}$ -V
293	1x6	5 $\frac{1}{2}$	5	$\frac{1}{4}$ -V
294	1x8	7 $\frac{1}{2}$	7	$\frac{1}{4}$ -V
295	1x10	9 $\frac{1}{2}$	9	$\frac{1}{4}$ -V
296	1x12	11 $\frac{1}{2}$	11	$\frac{1}{4}$ -V

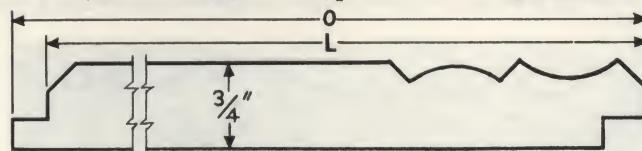
†Net thickness is $\frac{25}{32}$ ".

*Net thickness is $\frac{9}{16}$ ".

Shiplap paneling also includes the following variations:



Pattern No.	N	O	L	Edge
310	1x6	5 $\frac{1}{2}$	5	$\frac{5}{16}$ -Rounded
311	1x8	7 $\frac{1}{2}$	7	$\frac{5}{16}$ -Rounded
312	1x10	9 $\frac{1}{2}$	9	$\frac{5}{16}$ -Rounded
313	1x12	11 $\frac{1}{2}$	11	$\frac{5}{16}$ -Rounded



Pattern No.	N	O	L	Edge
520	1x8	7 $\frac{1}{4}$	6 $\frac{15}{16}$	V & Mold
521	1x10	9 $\frac{1}{4}$	8 $\frac{15}{16}$	V & Mold
522	1x12	11 $\frac{1}{4}$	10 $\frac{15}{16}$	V & Mold

For more details on patterns see CRA booklet "Standard Patterns of Worked Redwood Lumber." For suggestions on interior finishes, see CRA data sheet 4B4-1. Information on installing paneling and applying finishes is contained in CRA data sheet 3A7-2.

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ARCHITECTURAL DECORATION

At Right: Detail of church at Eagle Rock, California, designed by Thomas Franklin Power, architect. Below: General view of building.

Two considerations determine the choice of a wood species for external ornamentation: Ability to withstand weathering when in place, and workability.

In the first of these, Redwood ranks in the top classification as it can be exposed to the weather without material physical changes, such as warping, splitting, or checking, taking place. It also possesses high ability to preserve its own surfaces without protective coatings. It is rated by



the Forest Products Laboratory as one of those woods which "hold paint longest and suffer least when protection against weathering becomes inadequate."

Redwood also ranks high in the second characteristic for this use. It is easily worked with either hand or machine tools, due to its comparative uniform cellular structure and the absence of great difference in texture between its springwood and summerwood. With proper tools, it is possible to get smooth surfaces even when cut across the grain.

Its working characteristics are demonstrated by its frequent use as a pattern material for foundry castings, etc. It is also easily obtainable in large knot-free pieces suitable for architectural decoration. On these pages are shown three buildings in which Redwood plays an important decorative role.



Above: Redwood beam ends on public building designed by John Galen Howard, architect. The wood has no paint or other finish but has been allowed to weather to a natural darkness to contrast with the granite walls of the building.



Right: Carved Redwood lintels by a student of Charles Marshall Sayers, sculptor. No paint or other decoration has been used. Note particularly the complexity of detail, made possible by the uniform texture of the material.

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REDWOOD SIDING: Application

Redwood is widely used for siding because it will lay flat and resist weathering in all climates even when used without protective finishes. It also holds paints and natural finishes better than most wood species. None retain a finish better than redwood.

Grades: Clear All Heart grade is used for quality siding with or without a finish. Vertical grain Clear All Heart is a special selection available in some patterns, having exceptional characteristics in finish retention

as well as resistance to weathering if left unfinished. A-Grade is a clear grade of similar quality which includes the cream-colored alburnum (sapwood).

Dryness: The use of properly kiln-dried siding is important for quality construction. Look for the "CRA—CERTIFIED DRY" grade mark as evidence that the lumber has been graded and seasoned to the exacting standards of the California Redwood Association.

PROPER HANDLING

All wood siding should be kept under dry cover when delivered to the job. Moisture collected in the wood may cause paint difficulties later. Care should be taken also to avoid marring it and to keep it clean, especially if a natural finish is to be used. Oil or grease particularly should be avoided because they penetrate deeply into the wood and are difficult to remove.

PREPARATION

Priming. When it arrives at the job, the siding should receive a prime coat on face, back, and ends to seal out moisture. This is desirable with all wood species to prevent the possibility of water blisters, bleeding, or other causes of finish failure. Use the same material for the prime coat as for the final coats, thinning only according to the paint manufacturer's recommendations for prime coats. The prime coat prevents moisture getting into the siding during construction, provides a surface that is easily cleaned before final coats are applied, and forms a good base for the final coats.

End-sealing. Freshly cut ends that develop during construction should be sealed, since end-grain is very absorbent. If the redwood siding is to be left to weather without any finish, or is to be treated with a bleach, the end-grain should be sealed with a liberal application of a water-repellent sealer.

WEATHER TIGHT CONSTRUCTION

Building Paper. Poor construction details may enable water to seep into the siding and cause paint deterioration later. A water-repellent building paper should be applied to the sheathing (or placed across studs if no sheathing is used) in order to block water penetration. This material should not be a vapor barrier, for if vapor has once gained access into the wall, it should be allowed to breathe out to prevent water-logging of the wall. (See below for discussion of vapor barrier.)

It is structurally desirable to back up the thinner siding patterns with sheathing, and in the colder climates sheathing is advisable even with thicker siding. Wood sheathing increases the insulation quality of the wall, and diagonally laid up sheathing also adds to its strength.

Careful Fitting. Bevel siding should have sufficient lap in order to prevent wind-driven rain from working up between courses. Use at least a one inch lap for a six inch face width, at least three-quarter inch lap for narrower, and one and one-half inch lap for wider faces.



When delivered to the job, siding is stored under cover to keep it dry and given a prime coat to seal out moisture.



End-grain is very absorbent, should be sealed when siding is primed. Also end-seal newly cut pieces as they occur during construction.

Accurate cutting for tight fitting joints is important. Mitered corners, sometimes used with the thicker patterns, should be cut in a miterbox. Nail mitered ends to the corner post—not to each other. If corner boards are used, siding ends should butt snugly to the boards. Metal corner caps are sometimes used to protect corner joints of horizontal courses. Care should be taken to see that these fit tightly.

Caulking (or sealing) of all joints will provide further protection against rain, snow, fog, or wind seepage, and is particularly important at the butt joints of short length siding laid vertically. Careful attention in fitting should be given the corners of trim and molding, and at the juncture of the siding with window frames, door frames, and with the foundation. Other areas which must be carefully checked are gutter joints and downspouts.

Flashing. Surface junctures over door and window frames, and around dormers, require flashing to drain away water. The flashing should be anchored tightly and should extend well over edges and ends of well-sloped water tables to prevent water from running in behind siding or jambs.

Foundation Line. It is preferable that the lowest edge of the siding be at least six inches above ground level to prevent its collecting moisture by capillary action. A full-film finish or aluminum-based paint will provide an effective seal on the lower edge of the bottom course. Particularly the end-grain at the bottom of vertical siding should be well sealed. The use of a drip cap at the lower edge of the siding will help direct down-flowing water away from the foundation. It is also desirable to have the ground adjacent to the wall sloping away from the house, to assist drainage.

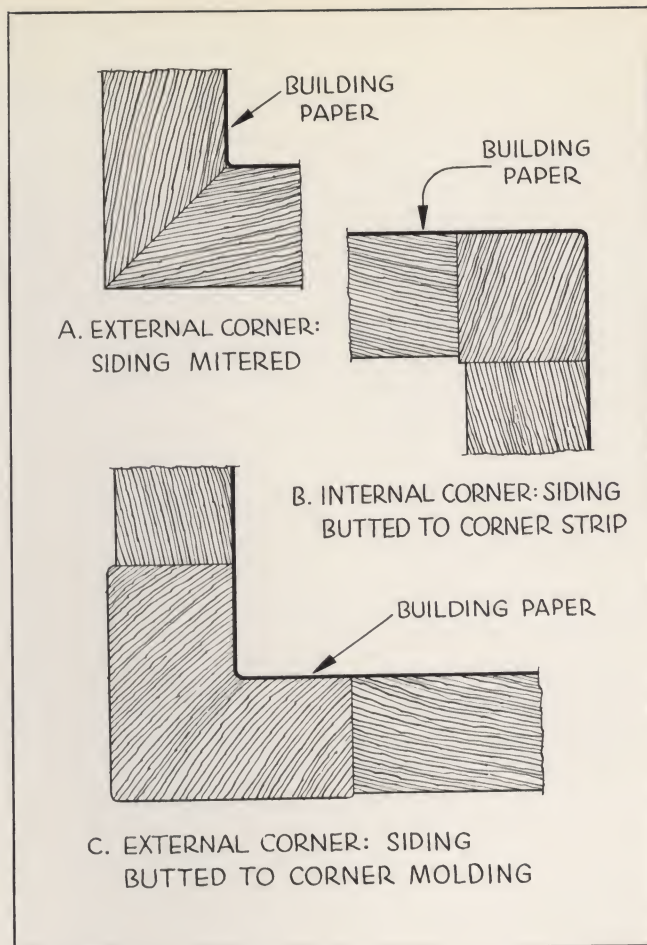
REDUCING CONDENSATION

Moisture Vapor. Changes in construction practices and domestic habits have contributed to a great increase in the amount of humidity occurring in houses in cold-weather areas. Modern insulation, the use of storm windows, and weather-stripping, as well as the heating equipment and many appliances in today's home keep houses warmer and contribute to a build-up of humidity within. This invisible moisture is one of the least understood and most troublesome causes of finish failure today.

It moves as moisture vapor from the warm interior of the house toward the cold exterior. This vapor travels through

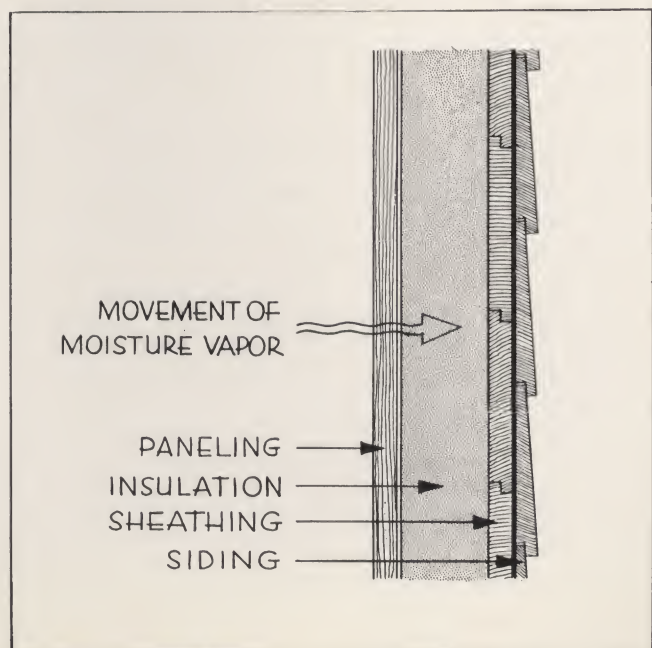


Vulnerable places over door and window frames are fitted with flashing, which should extend well under the siding.



plaster, insulation, and wood, until it condenses into water at the colder exterior surfaces of the sidewall. This water in the siding can cause blistering, peeling, and staining of the finish film. It can cause bleeding by bringing water-soluble extractives to the surface of the siding.

Vapor Barrier. It is important to prevent this condensation by installing vapor barriers on the warm sides of the



Vapor, if unchecked, moves from humid interior toward colder exterior, and condenses on inner surfaces of siding.



The vapor barrier is located as close as possible to the warm surfaces of the sidewall. Install between insulation and interior paneling.



Building paper, placed just behind the siding, blocks water seepage. Not a vapor barrier, it allows any vapor trapped within stud spaces to breathe out.

walls, between the insulation and the interior paneling (or plaster). Some insulation is manufactured with an integral vapor barrier. The vapor is then channeled out of the house through the wall vents.

Ventilation. Attic areas should be adequately vented to prevent vapor from condensing on cold surfaces in this area of the house. Water vapor may easily penetrate through the ceiling into the attic. Louvered vents are generally used to provide humidity control in the attic. Critical sources of humidity such as the kitchen, bath, and laundry are best ventilated by means of exhaust fans.

The crawl space should be well ventilated all around the house in order to allow this area to dry out. A basement may also be a source of considerable dampness and requires effective ventilation in order to eliminate humidity.

Movement of vapor into stud spaces and walls from crawl spaces occurs as the result of water evaporating from the ground under the house. This movement can be retarded by laying asphalt impregnated roll roofing (55 lb. roll per 108 sq. ft.) along the ground. Lap paper two inches at joints, but do not fasten. Plastic film may also be used for this purpose.

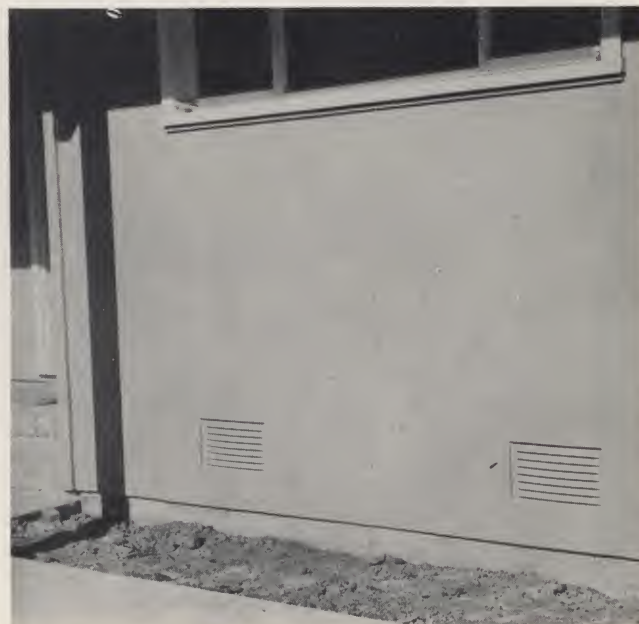
Small venting devices are sometimes added at the top and bottom of all stud spaces to further insure adequate dryness of the sidewall. Some consist of little metal tubes which are emplaced through the siding and sheathing.

APPLYING THE SIDING

Proper nailing begins with selection of right nails. The fastenings should be as durable as the redwood they are intended to hold. Aluminum or hot-dipped galvanized nails are recommended for exteriors to eliminate nail stains. Com-

mon wire nails or cement coated wire nails are not recommended for outside work. **Note:** If a natural finish is to be applied, use a non-oily wood filler whenever nails are countersunk; this will prevent oil stains.

Choice of size and type of nail will depend upon what is being nailed—and where. Nails should be long enough to penetrate into studs (or studs and wood sheathing combined) at least 1½ inches. Where this much penetration is not pos-



Ventilation of closed spaces should admit outside air, but exclude rain. Crawl space should be fully vented.

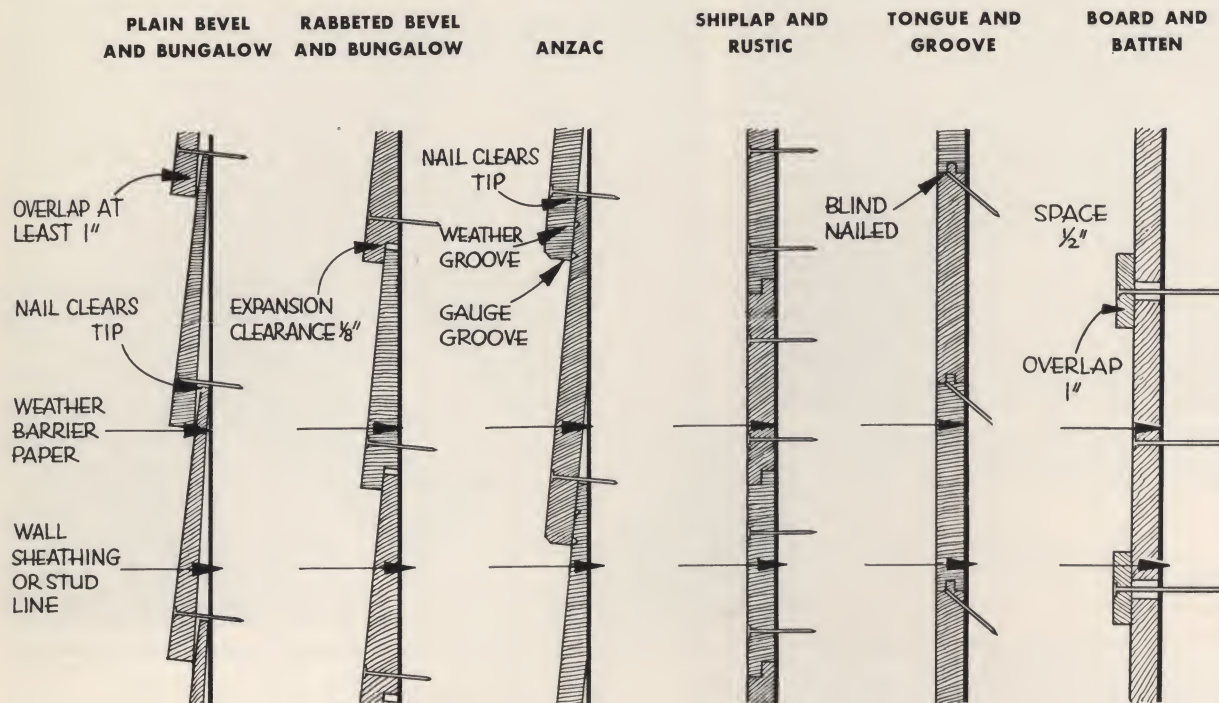
sible, deformed (threaded) nails are sometimes used to increase holding power.

In order to prevent splitting, allow expansion clearance for lapped siding—do not nail through tip of undercourse. When nailing mitered corners, or near the end of a piece, pre-drill the nail hole or blunt the nail point slightly. When

siding courses are laid up vertically, use 2x4 blocking between studs. These girts are placed at top, bottom and immediately at not more than 24 inches on centers.

All nailing recommendations refer to siding applied for exterior use, and all refer to nailing at every stud. (See sketches.) Some local building codes may require different nailing patterns.

SUGGESTED NAILING METHODS



Bevel and Bungalow. Face nail with one nail per bearing only. Use 8d siding nails for 3/4-inch thickness, 6d siding nails for thinner siding. **Plain:** Drive nail so that the shank just clears the tip of preceding undercourse. **Rabbeted:** Set courses to allow expansion clearance of 1/8 inch. Drive nail approximately one inch from the lower edge of the course. (See data sheet 3A4-4.)

Anzac. Face nail, one 8d nail per bearing, so that shank just clears tip of undercourse. Use a furring strip behind the lower edge of starting course to provide support. Lower edge of each course is set just to cover the gauge groove on the face of the preceding undercourse. (See data sheet 3A4-5.)

Shiplap and Rustic. Face nail with two siding nails per bearing for patterns wider than six inches. Space the nails at quarter points from each edge of the piece. For narrower courses one nail per bearing is adequate, with the nailing point one inch from the overlapping edge. Use 8d siding nail for one inch thickness, 6d siding nail for thinner pieces. (See data sheet 3A4-3.)

Tongue and Groove. Narrow widths are blind nailed, one nail per bearing, through the tongue. For patterns eight inches and wider, face nail with two 8d siding nails per bearing. (See data sheet 3A4-6.)

Board and Batten. Fasten underboard with one 8d siding nail per bearing, driven through center of the board. Space underboards about 1/2 inch apart. One 10d siding nail per bearing is driven through center of batten strip so that shank passes between edges of underboards. (See data sheet 3A4-2.)

Additional information on withdrawal resistance and characteristics of nails is contained in data sheet **4A1-1, Nails and Nailing**. Information on characteristics and use of various timber fastenings is contained in data sheet **4A1-2, Timber Fastenings**. Information on exterior finishing is found in data sheet **4B3-1, Exterior Finishes**.

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BOARD and BATTEN WALLS



Richard J. Neutra, A.I.A., architect.

Board and batten construction originated from the need for an easily constructed, weather-proof exterior which could be made inexpensively from rough lumber. In the west, redwood became a standard material for board and batten because redwood boards lay flat, without the tendency to cup typical of many other species.

CURRENT USAGE

Architects have found that the board and batten wall has many advantages which justify its extensive use:

The effect is appropriate to contemporary design, and the scale is easily varied by changing the sizes of the pieces used.

It is economical to erect, for it lays up rapidly without skilled labor.

Material is economical since no special mill work is required. It rarely requires long pieces of lumber, and utilizes trims to advantage around windows and doors.

It gives good wall coverage with a minimum of material and is very weather tight.

VARIATIONS

The usual manner of application is a vertical placement of wide boards with narrow batten strips. Two variations are occasionally used—

the "board-and-board" in which all pieces are of equal or nearly equal width, and the "inverted" or "recessed" batten in which the narrow pieces are placed against the wall with the wider pieces outside.

Frequently rough or resawn boards are preferred because of the textural effect, and because finishes tend to hold up longer on them. Surfaced stock is also readily available in boards or battens, and sometimes a special pattern is used for batten strips.

Appropriate use of any of these variations is found in both exteriors and interiors.

ADVANTAGES OF REDWOOD

Redwood is particularly suited to board and batten construction because the wide pieces used require a stable wood—one that will not swell and shrink extremely with changes in moisture conditions. The boards will lay flat and smooth, despite years of exposure even without any protective finish.

Very few species other than redwood are durable enough to be used without a finish coat, and no wood species surpasses redwood in the ability to hold natural finishes or paints if such application is to be used.

The excellent insulation value of redwood (k factor = .76) contributes to maintenance of comfort at minimum cost.





Mario Galdano, A.I.A., architect.

SPECIFICATIONS

Grades. For quality architectural work kiln-dried redwood boards are available, either rough, resawn, or dressed, in the two finish grades, Clear All Heart and A-Grade. Economical cuttings for short lengths can be obtained from kiln-dried Shop grade.

For reasons of greater economy or for special architectural effect, the construction (common) grades are occasionally used in board and batten construction.

Priming. If a finish is to be used, the lumber should be face and back-primed and the ends sealed with paint or water-repellent sealer. If the redwood is to weather without a finish, it should be back and end-primed with a water repellent.

Nails. For exterior work, use aluminum or hot-dipped galvanized nails to assure fastenings that are as durable as the redwood they are intended to hold. Nail size should allow a penetration into studs (or studs and wood sheathing combined) at least one and one-half inches. If this much penetration is not possible, nails with deformed (threaded) shanks are sometimes used to increase holding power.



Variations in the thickness and spacing of battens will determine the emphasis on shadow lines. Chaix and Johnson, architects.

Nails may be either flush or countersunk. Care should be taken, however, in choice of fillers for countersunk nail holes. If a natural stain or clear finish is to be applied, use a non-oily wood filler in order to avoid oil stains.

APPLICATION

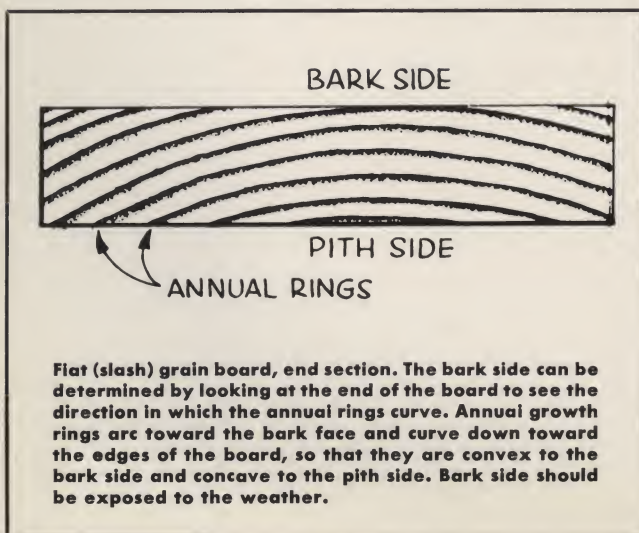
Placing Boards. Board and batten is generally laid up vertically. Use horizontal blocking at top and bottom, and intermediately at not over 24 inches on centers. The underboards, spaced approximately one-half inch apart, are nailed to studs or blocking.

Flat grain boards should be laid up with the bark side exposed to the weather, for best resistance to checking (see sketch). Either side of vertical grain boards will weather excellently.

If used over a water table, bottom ends should be beveled to a suitable angle.

Fastening. One of the advantages of board and batten construction is that it makes possible the use of nailing methods which allow the boards some freedom to move slightly with changes in humidity and temperature. A preferred method is to drive one nail through the center of the board at each bearing. This allows the edges to "float" slightly.

Battens. After underboards are fastened, apply batten strips. Battens should overlap each edge of the boards



underneath at least an inch. Drive nail directly through the center of the batten so that the shank passes between the underboards.

Prevent Splits. When nailing near the end of a piece it may be desirable to drill a lead hole. This reduces the likelihood of splitting during nailing. Another effective method is to blunt the nail point slightly with a hammer.

NAILING DETAILS



STANDARD BOARD AND BATTEN: One 8d siding nail is driven midway between edges of the underboard, at each bearing. Then apply batten strips and nail with one 10d siding nail at each bearing so that shank passes through space between underboards.



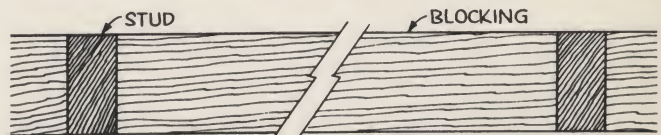
SPECIAL BATTENS: A T-shaped batten, or standard batten nailed over a vertical nailing strip, is nailed exactly the same as the standard method; however, in this case an exceptionally good bearing is provided while driving nail through the batten.



BOARD-ON-BOARD: Apply underboards first, spacing them to allow 1 1/2-inch overlap by outer boards at both edges. Use standard nailing for underboards, one 8d siding nail per bearing. Outer boards must be nailed twice per bearing to insure proper fastening. Nails, having some free length, do not hold outer boards so rigidly as to cause splitting if there is "movement" from humidity changes. Drive 10d siding nails so that shanks clear edges of underboard approximately 1/4 inch. This provides sufficient bearing for nailing, while allowing clearance to enable underboard to expand slightly.



REVERSE BATTEN: Nailing is similar to board-on-board. Drive one 8d nail per bearing through center of under strip, and two 10d siding nails per bearing through outer boards.



HORIZONTAL BLOCKING: Use 2 x 4 girts between studs, 24 inches on centers.



White Oaks Elementary School Annex. John Carl Warnecke, A.I.A., architect.

DRESSED SIZES FOR REDWOOD YARD STOCK

STRIPS, BOARDS, DIMENSION

THICKNESS*		WIDTH*		
ROUGH (Nominal)	DRESSED S1S or S2S (a)	ROUGH (Nominal)	DRESSED S1E or S2E (b)	DRESSED (Dry Finish) S1E or S2E (c)
1	$2\frac{5}{32}$	3	$2\frac{5}{8}$	$2\frac{5}{8}$
$1\frac{1}{4}$	$1\frac{1}{16}$	4	$3\frac{5}{8}$	$3\frac{1}{2}$
$1\frac{1}{2}$	$1\frac{3}{16}$	5	$4\frac{5}{8}$	$4\frac{1}{2}$
2	$1\frac{3}{4}$	6	$5\frac{5}{8}$	$5\frac{1}{2}$
		8	$7\frac{1}{2}$	$7\frac{1}{4}$
		10	$9\frac{1}{2}$	$9\frac{1}{4}$
		12	$11\frac{1}{2}$	$11\frac{1}{4}$

*The thicknesses apply to all widths and the widths to all thicknesses. All measurements given in inches.

(a) Surfaced thicknesses for all yard grades, green or dry.

(b) Surfaced widths for green Clear All Heart and A-Grade, and for all other yard grades, green or dry.

(c) Surfaced widths for dry Clear All Heart and A-Grade in above thicknesses.

There is also available standard mill pattern #558, which is a $\frac{1}{2}$ " x 3" batten (S1S2E to $1\frac{1}{32}$ " x $2\frac{1}{2}$ ").



Monterey Airport. Robert R. Jones, A.I.A., architect.



Residence in Maryland. Keyes and Yurchenko, architects.



Residence designed by Greta Magnusson Grossman.

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TONGUE AND GROOVE WALLS

One of the most versatile sidings is provided by the tongue and groove pattern. Laid either vertically, horizontally, or at an angle, it provides a perfectly weather-tight wall.

CURRENT USAGE

In modern architecture, the pattern finds many uses. Without V or eased edges, it lays up perfectly flat and gives only a slight accent to the direction in which laid. These patterns are used where simplicity is desired, with only the figure and grain of the wood to give texture to the wall.

Somewhat greater emphasis on the direction of the pieces may be obtained by using one of the eased edge patterns. These have the corners slightly rounded to give a faint line to the wall.

If full effect of the individual pieces is desired, the pattern is available with two depths of V-joint. These patterns are most useful for the effect they have on dimensions. The shadow lines are sufficient to increase the horizontal or vertical effect, depending on the direction in which they run.

For the contemporary home, with its simple direct design, California redwood siding is most often used vertically. The long slim lines add an illusion of height to the generally low horizontal lines of the walls.

VARIATIONS

By selecting the width of siding, the scale of lines and shadows may be suited to the individual wall. Some of the most attractive work has used a variety of widths in the same wall. This has two possibilities. Either repeat the widths in sequence, or in a definite pattern; or put them up at random. The standard widths for most tongue and groove patterns are four inch through eight inch.

These patterns are available in both flat and vertical grain. Vertical grain, because of its fine

texture, lends itself well to interiors of a more restrained character, and it is often preferred for exterior work where exposed to the full effects of the weather. The more highly figured flat grain, however, is usually preferred for interior use, and for exterior use around porches and patios where the distinctive characteristics of each board may be shown to advantage.

ADVANTAGES OF REDWOOD

The uniform thickness of these patterns, with redwood's high insulating properties, insures a cool room in summer and comfort in winter at a minimum of cost. The low shrinkage factor of redwood makes possible the tight joints so essential to the finished job and lasting satisfaction.

APPLICATION

Blind nailing is usually preferred in the narrower widths, four inch and six inch. Six-penny galvanized or aluminum finish nails are preferable for exterior work; wire finish nails for interior use. One nail per bearing is sufficient. If applied vertically, the siding is nailed to horizontal nailing strips which should be not more than 24 inches on centers. For face nailing the eight inch widths, two eight-penny nails per bearing are advisable. Siding nails should be used for exterior work; finish nails for interior work.

CONSTRUCTION NOTES

Good building practices should be followed in applying any siding. The pieces should be back and end-primed before installation, following the recommendations of the finish manufacturer whose product will be used for the final coat.

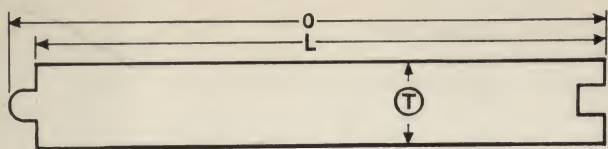
Nails used for exterior work should be hot-dipped galvanized or aluminum to avoid stains and to give the nails as long a life as the wood.



Random width tongue and groove siding, Buffalo, N.Y., Sebastian J. Tauriello, A.I.A., architect

PATTERNS

Tongue and groove patterns are manufactured in several standard variations: (N=nominal size. O=overall width. L=laid-up, or exposed, face width. T=finished thickness. All measurements in inches.)



Pattern No.	N	O	L	T	Edge
132	1x4	3½	3¼	²⁵ / ₃₂	Square
133	1x6	5½	5¼	²⁵ / ₃₂	Square
132EE	1x4	3½	3¼	²⁵ / ₃₂	Eased
133EE	1x6	5½	5¼	²⁵ / ₃₂	Eased
116*	1x6	5½	5¼	¾	¼-V
116½*	1x8	7½	7¼	¾	¼-V
207	1x4	3½	3¼	²⁵ / ₃₂	³ / ₃₂ -V
208	1x6	5½	5¼	²⁵ / ₃₂	³ / ₃₂ -V
209	1x4	3½	3¼	²⁵ / ₃₂	¼-V
211	1x6	5½	5¼	²⁵ / ₃₂	¼-V
212	1x8	7½	7¼	²⁵ / ₃₂	¼-V
213	1x10	9½	9¼	²⁵ / ₃₂	¼-V

*Also have center V same size as edge V.



Narrow T & G verticals finished to emphasize native grain and color, Carl Maston, architect



V-edge T & G redwood and brick form a contrast in linear patterns, San Francisco, Calif., John Kelley, architect



A wall in "A" Grade, with T & G joint, San Rafael, Calif., Fred Langhorst, A.I.A., architect



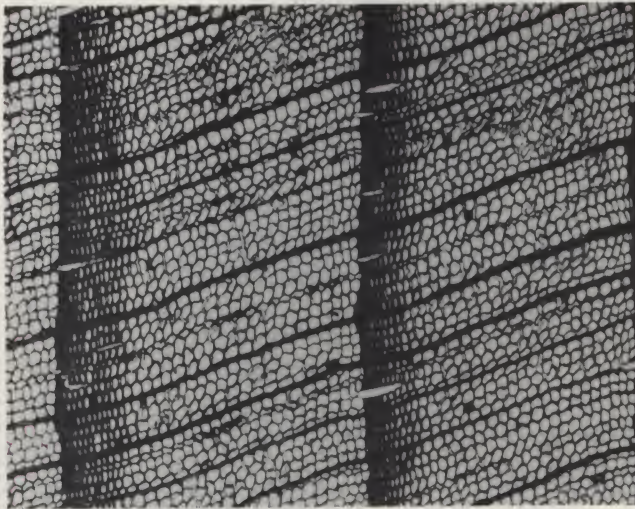
Vertical, horizontal and diagonal planes in natural T & G redwood, Berkeley, Calif., Harwell Hamilton Harris, architect

Redwood

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INSULATION PROPERTIES OF REDWOOD: HEAT, SOUND AND ELECTRICITY



A cross section of redwood as seen through a microscope. The tiny air-filled cells retard heat transmission.

Insulation is the property of a material which impedes the transmission of energy in the form of heat, sound or electricity. California redwood possesses good insulation characteristics in all three cases.

INSULATION AGAINST HEAT AND COLD

The thermal insulation properties of building materials are becoming more important in residential, commercial and industrial building. Air-conditioning and climate control equipments are finding general application, and the efficient operation of these systems depends largely on the degree of insulation provided by the building shell. Since wood is so widely used for sheathing, siding, paneling, flooring and roofing, its thermal insulation properties are of special importance.

All species of wood provide a relatively high degree of insulation. The minute cell structure, with thousands of air-filled cavities per cubic inch, account for this property. The lighter, low density woods provide better insulation than the denser woods. Redwood, with a relatively low density (large percentage of air spaces in ratio to the wood substance) has an excellent insulation value.

k Factor

Insulating value is measured by the number of British thermal units which will pass, per hour, through one square foot of the material, one inch thick, for each degree of Fahrenheit temperature difference between the surfaces. This coefficient is called the "*k* factor." Values of the factor for several building materials are given in Table I; the lower the *k* factor, the better the material is as an insulator.

TABLE I

Material	<i>k</i> factor	Inches of Thickness Needed to Equal 1" of Redwood in Insulating Value
Redwood	.76	1.0
Built-up roofing	1.33	1.7
Gypsum board	1.40	1.8
Plaster	3.30	4.3
Clay tile	4.20	5.5
Brick	4.80	6.3
Glass	5.46	7.2
Cement block	7.20	9.5
Concrete	11.40	15.0
Stucco	12.50	16.5
Aluminum	1416.00	1863.0
Insulating board (softboard)	.33	.4

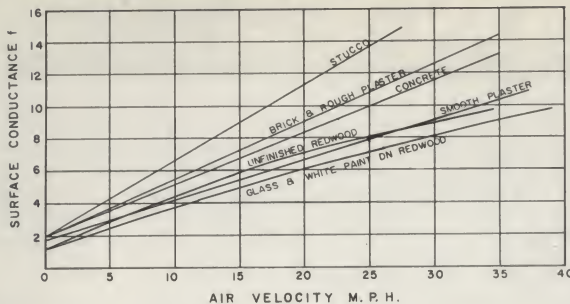
A dead air space, at least $\frac{3}{4}$ " in thickness, has a comparable *k* value of 1.10, but this does not increase materially as the air space becomes greater.

While the *k* factor is the basic measure of insulating efficiency, it usually can be used directly only in comparing the efficiencies of various materials. Since it applies to only one material just one inch thick, and does not account for heat transfer to and from the material, it cannot be used alone to compute the relative insulating value of a complete section composed of several materials of different thickness.



In many architectural uses, the thermal insulating properties of redwood are very important. Ward Thomas, Architect.

Fig. 1: Surface Conductance at Various Air Velocities



U Factor

In construction work, the insulating figure most commonly used is the U factor. This is the over-all coefficient of heat transmission through a section. It includes the k factor and thickness of each material through which heat must pass, and it also includes the value of any dead air spaces and the surface conductance on both sides.

$$U = \frac{1}{\frac{1}{f_i} + \frac{x_1}{k_1} + \frac{x_2}{k_2} + \frac{x_3}{k_3} + \dots + \frac{1}{f_o}}$$

f_i and f_o = Heat transfer coefficients from air to the inner and outer surfaces. (Figure 1).

x_1, x_2, x_3 , etc. = Thickness, in inches, of various materials in the section.

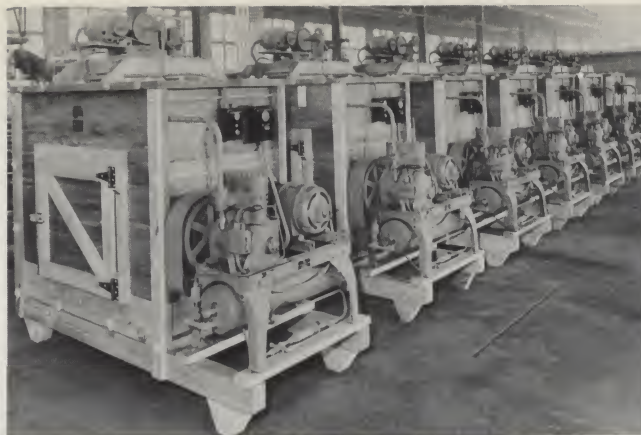
k_1, k_2, k_3 , etc. = Thermal conductivity factors of the various materials. (Table I).

U factors for various wall sections are given in Table II; the lower the factor, the better the insulating properties of the section. Minimum outside design temperatures (based on FHA requirements) for which the various sections are satisfactory, have been computed by assuming inside temperature of 70° and inside relative humidity of 60 percent. They are shown in the right hand column of Table II.

Heating and cooling loads will be inversely proportional to the U factors. That is, a frame wall with redwood paneling and siding will have approximately three-fifths the heat loss of a cement block wall with lath and plaster interior finish (the ratio of .21 to .34.)

Due to the different combinations and thicknesses of materials that are possible, it is not practical to tabulate the U factor for all possible types of construction. However, with the k factors given in Table I, the surface conductance values from Figure 1, and the basic equation for U , the factors for various sections may be determined.

Wind velocities increase the rate of heat transfer as shown in Figure 1. For general calculations, a wind velocity of 15 M.P.H. is assumed.



Freezer units used for making and storing crystalform ice for food packing testify to the low heat transfer rate of redwood.

TABLE II
TYPICAL WALL SECTIONS

Typical Section and Exterior Finish	Interior Finish	U Factor	Outside * temperature, °F.
REDWOOD SIDING 	Redwood Paneling, 3/4"	.21	-30
	Gypsum Board, 3/8"	.25	-20
	Lath & Plaster	.26	-17
BRICK VENEER (4") 	Redwood Paneling, 3/4"	.22	-27
	Gypsum Board, 3/8"	.27	-15
	Lath & Plaster	.27	-15
STUCCO (1") 	Redwood Paneling, 3/4"	.26	-17
	Gypsum Board, 3/8"	.34	+ 4
	Lath & Plaster	.34	+ 4
CEMENT BLOCK (8") 	Redwood Paneling, 3/4"	.26	-17
	Gypsum Board, 3/8"	.33	0
	Lath & Plaster	.34	+ 4

PLANK AND BEAM OR SINGLE WALL CONSTRUCTION

Typical Sections	Components of Section	U Factor	Outside * temperature, °F.
PLANK & BEAM 	1" Redwood	.53	+36
	1" Redwood + Built-up Roof	.46	+28
	2" Redwood	.31	- 5
	2" Redwood + Built-up Roof	.29	- 7
SINGLE WALL 	2" Redwood + 1/2" insulating board and Built-up Roof	.20	-32

* Assuming inside temperature of 70°F.

Example: To determine the U factor for a 2" T&G redwood roof with $\frac{3}{8}$ " built-up roofing over a $\frac{1}{2}$ " fiber insulation slab; wind velocity 15 M.P.H.; surfaced thickness of redwood $1\frac{3}{4}$ ":

k for redwood76

k for insulation33

k for roofing 1.33

From Figure 1, $f_i = 1.4$ and f_o is assumed as 6.0

$$U = \frac{1}{\frac{1}{1.4} + \frac{1.75}{.76} + \frac{.5}{.33} + \frac{.38}{1.33} + \frac{1}{6.0}} = .20$$

The U factor is generally used in specifications, since it is an exact expression of the heat loss through a section, per degree difference in temperature between inside and outside surfaces.

If the U factor of the typical section desired is not low enough to meet requirements of the minimum outside temperature of the area, an alternate interior or exterior finish may often be selected to give the proper factor. For example, the third wall section in Table II, using wood paneling and stucco, does not have a low enough factor to be safely used if temperatures drop to -30 . This temperature requires a factor of .21. Using $\frac{3}{4}$ " redwood siding in place of the stucco would drop the factor from .26 to .21, and the section would then be suitable for use under these extreme conditions.

TOTAL HEAT TRANSFER

Sometimes it is necessary to go one step further and compute H , the actual heat loss through the section under given temperature conditions.

$$H = U(t_i - t_o) = \text{Btu per hour per square foot of area}$$

t_i = Inside room temperature

t_o = Outside temperature

Example: Compute H for the previous example if

$$t_i = 70^\circ, t_o = 0^\circ$$

$$H = .20 (70 - 0) = 14 \text{ Btu/hr./sq.ft.}$$

CONDENSATION

In some installations, particularly where high humidities must exist in the building, it is desirable to compute the temperature, t_x , on the inner surface of the section to determine



Chicken incubators require extremely close temperature control. Here, redwood is used for the structural casing.

whether or not condensation is likely to occur on the inner surface at the temperatures and humidities contemplated.

$$t_x = \frac{f_i t_i - H}{f_i}$$

Example: Compute the temperature of the inner wall surface in the previous example:

$$t_x = \frac{(1.4 \times 70) - 14}{1.4} = 60^\circ$$

Reference to psychrometric charts or tables will determine the relative and absolute humidities that have this temperature as their dew point.



Unbroken wall of redwood serves as an effective sound barrier between apartment house and noisy thoroughfare. Carl Maston, Architect.

SOUND INSULATION

The amount of sound absorbed by various building materials is usually compared to that absorbed by an open window. The coefficient of the window is set at 1.00; and all other materials have factors indicating their percent efficiency, compared to the opening.

TABLE III
SOUND ABSORBING COEFFICIENTS FOR
512 VIBRATIONS PER SECOND

Material	Coefficient per Square Foot
Open window	1.00
Wood, plain	.06
Wood, varnished	.03
Brick	.03
Cork tile	.03
Plaster	.03
Marble	.01

Sound transmission through wall sections cannot be determined by any simple equation, since it depends on so many factors. Tests on various types of construction indicate that a stud wall with wood paneling on both sides may be expected to absorb between 40 and 60 decibels at frequencies between 256 and 1024 cycles per second; 50 decibels is average noise level for a restaurant and 60 is average for a busy street. Therefore, this absorption coefficient gives adequate sound insulation for all but the most intense noise.

ELECTRICAL INSULATION

Dry redwood has a very high electrical resistance. The resistance drops off as the moisture content of the wood increases.

TABLE IV

**ELECTRICAL RESISTANCE OF REDWOOD IN MEGOHMS AT 80°F.
AND VARIOUS MOISTURE CONTENTS**

Moisture Content, Percent	Resistance, Megohms*
7	22,400
8	4,680
10	615
12	100
14	22
16	7.2
18	3.2
20	1.7
22	1.0
24	.7

*Measured along the grain by two pairs of needle electrodes, 1¼ inches apart, driven 5/16 inch into the wood.

At ten percent moisture content, the average in use, redwood is considered an effective non-conductor of electricity. Where electrical insulation is particularly important, the wood is dried to a lower moisture content and coated with a sealer to reduce subsequent moisture absorption.



Redwood frame supporting electrical laboratory equipment handling 200,000 volts.

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NAILS and NAILING



For satisfactory results, nails should be selected for proper size, right type of head, and adequate holding power for the job. Nails for exterior use should be corrosion resistant, and should not discolor the wood.

DURABILITY

Since redwood is a durable wood, it is important that the nails be as lasting as the wood itself. Aluminum nails are the most satisfactory fastening for exterior woodworking. They do not corrode, nor do they discolor or deteriorate the wood. Hot-dipped galvanized nails also provide durable service; however, in some cases the galvanizing flakes off during driving so that the steel is exposed. Slight discoloration of the wood may result.

Copper, stainless steel or monel nails are used in industrial applications where conditions dictate the use of a particular metal. Stainless steel and the monel have not been observed to deteriorate in contact with redwood or to discolor it. Copper nails are durable, but they discolor redwood slightly and cause some deterioration.

Plain steel nails and cement-coated steel nails should not be used on exterior redwood, or in interior work where the wood may be wet or moist. Cement-coated nails rust as readily as uncoated nails.

In rusting, the nail expands, enlarging the hole in the wood. As the rust flakes away contact between nail and the wood is lost and nail-holding power is decreased. Even before the nail and the wood show marked deterioration, the steel causes unsightly black stains on the redwood.

NAIL HEADS

Four common forms of nail heads are used with redwood:

Siding Nails: For all exterior sidings, except 4" and 6" tongue and groove, the siding nail gives best results. The head is slightly tapered and can be driven flush or countersunk without crushing the surrounding wood.

Casing Head: Some manufacturers produce a casing head siding nail which is ideal if countersinking is desired.

Finish Nails: For blind nailing 4" and 6" tongue and groove, and for all interior face nailing, finish nails are most satisfactory because they can be countersunk and filled over with the least difficulty.

Common Nails: For framing and similar structural work,

where strength is of more importance than appearance, common nails are used. These have larger heads than either siding or finish nails. The smaller common nails are sometimes used for siding, particularly if the heads are to be driven flush and not countersunk. If these heads are countersunk they tend to dent and crush the wood fibers excessively.

SPECIAL NAIL FORMS

The nails mentioned above all have smooth, round shanks and diamond points. They are satisfactory for all general work.

Special nails are made with spiral, annular or longitudinal grooves, or with barbs to increase withdrawal resistance.

Various points are also available for special jobs. A needle point will increase holding power, but causes a wedging action that increases the tendency to split. Chisel points have no particular advantages with redwood, and tend to split the wood. If used, the chisel should be driven across the grain, not parallel to it. Blunt pointed nails are available in some sizes. These have an advantage in less tendency to split the wood, but their withdrawal resistance is slightly less than standard diamond pointed nails.

WITHDRAWAL RESISTANCE

Nails driven perpendicular to the grain have maximum resistance to withdrawal. This resistance decreases as the angle to the grain decreases, and is at a minimum when the nail is driven parallel to the grain (into the end of a piece). Nails driven parallel to the grain have a holding power as low as 50% of those driven perpendicular to the grain.

When a nail is driven perpendicular to the grain into a piece of seasoned redwood, the force required soon afterward to start its withdrawal may be expressed as:

$$P = 6900 G^{2.5} D$$

P = ultimate pounds per linear inch of penetration

G = specific gravity based on oven dry weight and volume when oven dry

D = diameter of the nail in inches.

Applying a factor of safety of 6 to this equation, the safe load becomes:

$$P = 1150 G^{2.5} D$$

In the case of redwood with an average specific gravity of .42, the safe resistance to withdrawal becomes:

$$P = 132 D$$

TABLE 1—Safe resistance to withdrawal of common wire nails driven into seasoned redwood perpendicular to the grain.

(Values per linear inch of penetration into the main member receiving the point.)

Size of Nail	Pounds	Size of Nail	Pounds
6d	15	20d	25
8d	17	30d	27
10d	19	40d	30
12d	19	50d	32
16d	21	60d	35

LATERAL RESISTANCE

The safe lateral resistance for common wire nails driven perpendicular to the grain in redwood at 15% moisture content is expressed by the formula:

$$P = 1125 D^{3/2}$$

P = safe lateral load in pounds per nail.

D = diameter of nail in inches.

TABLE II — Safe Lateral Loads for Nails

Values assume that the nail penetrates the block receiving the point to a depth of at least 14 times the nail diameter. A factor of safety of 6 has been used in computing these values.

SIZE	PENETRATION (inches)	LOAD (pounds)	SIZE	PENETRATION (inches)	LOAD (pounds)
6d	1½	43	20d	2¾	95
8d	1¾	53	30d	3	106
10d	2	64	40d	3¼	120
12d	2	64	50d	3½	135
16d	2¼	73	60d	3¾	152

The withdrawal resistance and lateral resistance of spikes may be computed by the same formula.

NAILING

When it is necessary to nail close to the end of a piece, the nail should be driven into a pre-bored hole slightly smaller in diameter than the nail shank. This will decrease the possibility of splitting and increase holding power. If boring is not feasible, a blunt pointed nail should be used, or the point of the standard nail should be blunted before driving.

Paneling, trim and siding should be nailed to the framing members. Nailing to the sheathing is not adequate. This is particularly important if composition sheathing or insulation board is used because these materials have a lower nail-holding power than wood sheathing.

When it is necessary to butt-joint siding or paneling in a course, the joint should be over a stud or girt. The nails should be started well back from the end of the piece and driven at approximately 45° through pre-bored holes.

Countersinking: Nails may either be countersunk or driven flush with the wood surface:

Siding—If an opaque paint is to be used, the siding nails should be countersunk and puttied over. This hides the nail holes and provides a smooth surface for the paint. An oil-base putty is satisfactory. If a clear or a stain finish is to be used, it is preferable to drive the nail flush and not attempt to countersink. If it is necessary to countersink, fill the holes with a non-oily wood filler. Oil-base putties will produce discolorations on the wood which these finishes will not cover. The non-oily fillers will not discolor the wood, but the finish may not weather uniformly over the filler and the wood. The filler usually develops a lighter color.

Paneling—When face nailed, the finish nails used to apply paneling are nearly always countersunk. An oil-base putty may be used if paint is to be applied. If a clear or

stain finish is to be used, the hole should be filled with a non-oily wood filler. These fillers may be purchased in the redwood color, or may be tinted with dry color to match the wood. It is preferable to color the filler slightly darker than the redwood as it is less conspicuous in the darker values. (See CRA data sheet 3A7-2.)

NAIL SIZES

Siding: A general rule for selecting nail size is to allow at least 1½" penetration into the stud, or the stud and sheathing together. (See data sheets on each siding pattern for specific data on nailing siding.)

Ceiling: Blind nail once per bearing with 8d finish nails for 1" thickness; use 6d finish nails for less than 1" thickness.

Finish: Face nail with two nails per bearing, using 10d finish nails for 1¼" thickness, 8d for 1", and 6d for less than 1".

Flooring: Blind nail through tongue with 8d flooring brads.

Shingles and Shakes: Use 3d or 4d shingle nails, about one nail to each 4". Use 5d shingle nails for heavy butt shakes, or re-roofing new shingles over old shingles.

Miscellaneous: For platforms, floors and sheathing face nail with two 8d common nails per bearing for 1" x 4" to 10" widths. Three nails per bearing for wider. Use two 20d common nails for 2" x 4" to 8", and three nails per bearing for wider. Use 8d finish nails for base and face nail two per bearing. Use 3d fine nails for lath nailed 16" o.c. Use 6d and 8d casing nails for casing and 20d common nails for framing (2" x 4" to 2" x 16").

NAILINGS FOR STANDARD SIDING PATTERNS

Pattern	Nail Size And Type	Nails Per Bearing
Anzac	8d siding	1
Bevel Bungalow	8d siding for ¾" thickness 6d siding for thinner	1
Drop Siding Rustics Shiplap	8d siding for 1" thickness 6d siding for thinner	2
Tongue & Groove	6d finish for 4" and 6" 8d finish for 8" and wider	1 2

NAIL CHARACTERISTICS

SIZE	LENGTH (inches)		SIDING NAILS (No. per lb.)		FINISHING NAILS (No. per lb.)		COMMON NAILS (No. per lb.)	
	Aluminum	Galvanized	Aluminum	Galvanized	Bright	Galvanized	Bright	Galvanized
6d	1½"	2"	604	212	288	260	170	155
7d	2½"	2¼"	468	189	254	229	150	140
8d	2¾"	2½"	319	127	196	177	95	94
10d	2¾"	3"	185	83	124	112	65	61

Note: Casing Nails—6d is 2" long and 244 per lb., 8d is 2½" long and 147 per lb.

Fine Nails—3d is 1½" long and 757 per lb.

Shingle Nails—3d, 4d and 5d are 1¼", 1½" and 1¾" long, and 429, 274 and 235 per lb.

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REDWOOD FURNITURE CORES



In the long history of furniture manufacturing, very few woods have qualified as perfectly satisfactory core materials. The standards by which good cores are judged must, of necessity, be high. These materials should combine light weight with strength, be easy to work, form good glue joints with a wide variety of other materials and, most important of all, must hold their shape and be stable under changing temperatures and humidities.

PROPERTIES OF REDWOOD

This combination of desirable properties is found to a higher degree in redwood than in any other commercial American species.

Weight. The average specific gravity of redwood is .40. The average weight, at 8% moisture content, is 27

pounds per cubic foot. With this weight, redwood ranks as one of the lighter softwoods.

Strength. The strength properties of all woods are quite closely associated to the density or weight. Redwood has adequate strength for all the stresses that may be applied to furniture cores in use.

Workability. Redwood is relatively easy to work with either hand or machine tools. The general working characteristics of the wood have been analyzed by the U. S. Forest Products Laboratory, and redwood has been placed in Group 2, as a wood medium to work.

Good machining practices will produce a fine surface on either flat or vertical grain faces and edges. Of particular importance to the furniture

manufacturer is the shaping of end grain cuts. The detailed work done on this subject by the U. S. Forest Products Laboratory shows that redwood shapes more easily on the end grain than some other species generally used for cores.

Gluing. Both the heartwood and sapwood have been placed in Group 1 by the U. S. Forest Products Laboratory as woods that glue easily with a wide variety of glues under a variety of gluing conditions.

Dimensional Stability. Redwood has the lowest volumetric shrinkage of any commercial American wood. It shrinks and swells less, and has less tendency to cup or warp in changing moisture content. For a moisture content change of 1% the volumetric change is only .24%.

CLASSES OF PANELS

Although satisfactory commercial cores can be manufactured from mixed grain stock and from "A" Grade stock, which includes both heartwood and sapwood, stock should be selected for cores which must meet the most exacting requirements. Core stock may be segregated into the following groups:

1. Clear All Heart vertical grain.
2. Clear and "A" vertical grain.
3. Clear All Heart mixed grain.
4. Clear and "A" mixed grain.

The highest quality cores are made from group 1 stock. Excellent cores are made from group 2 or group 3 stock. Satisfactory commercial cores may be made from group 4 stock.

AVAILABILITY OF MATERIALS

Redwood is available in several forms for use as furniture cores. Shop grade is an economical way to buy and handle the cuttings. For plants wishing to make up their own cores, this grade should be investigated. Short lengths of Clear All Heart and "A" Grade are available from some mills. This material entails a minimum of waste and is inexpensive to handle and to work, but it is not as readily available as Shop grade. Redwood cores, already fabricated to standard specifications, are available to a limited extent.

NOTES ON CORE MANUFACTURE

Even if the cores are to be manufac-



These redwood cores, which contain heartwood, sapwood and mixed grain are used effectively in many products

tured within the plant, consideration should be given to the class of core. For reasons of economy the lowest class of core, which will give satisfactory service in the particular article, should be used. Only a few articles require the combination of fine characteristics found in a Clear All Heart vertical grain core. Most items can use one of the other classes.

Width of Pieces. The most frequently used widths are 2 to 8 inches. In vertical grain panels, pieces 8 and

10 inches wide give excellent performance. For flat grain panels, it is desirable to use widths under 8 inches for maximum stability. In general, it is best to strike a balance between the one extreme of using a few wide pieces, and the other of using many narrow pieces. The disadvantages of wide pieces are higher cost and more tendency, within the piece, to shrink. The narrower pieces, on the other hand, require more accurate machining and more glue lines. Between these two extremes, the most economical and satisfactory cores will be produced, depending on the overall width of the finished panel.

Machining and Gluing. Considerable information has been developed on the best machining and gluing practices to be followed for various types of work. In general, this may be summarized by stating that good, standard machining and gluing methods will produce excellent results with redwood. The details on these processes are covered in the references.

In preparing the individual pieces for gluing into panels, edge jointing is very important to reduce initial cupping. All pieces are usually jointed on



Surfacing the cores just prior to application of cross bands and face veneers

the same machine and are not usually mixed after jointing; so any variation from a vertical joint is cumulative and will produce a cupped panel.

Hot and cold pressed glues produce panels of equal flatness, but from overall considerations, the hot pressed glues will have slightly higher ratings.

USING REDWOOD CORES

After the cores are manufactured and are ready for use, certain steps should be followed to insure a satisfactory end product.

Conditioning for Moisture Content. The cores should be conditioned after gluing and before machining to prevent sunken joints. Any one of the following conditioning schedules should be satisfactory in removing excess moisture from the glue line:

- A. 7 days at 80° F. and 30% relative humidity.
- B. 4 days at 120° F. and 35% relative humidity.
- C. 24 hours at 160° F. and 44% relative humidity.
- D. 16 hours at 200° F. and 55% relative humidity.

If the cores are manufactured within the plant they should be ready for



Applying glue and cross bands

the final processing after this conditioning. If cores are brought in from outside sources, a conditioning period should be allowed to bring the panels to 6% moisture content before applying cross bands and face veneers. For simply removing moisture picked up in transit, 72 hours at 130° F. dry bulb and at 109° F. wet bulb temperatures will condition 1 inch panels to 6 or 6 1/2 % moisture content. A lower mois-

ture content is neither necessary nor desirable.

Cross Banding. Cross bands should be applied as soon after final surfacing as possible. Application within 24 hours is desirable, and at most not over 48 hours should elapse. Only through this practice can full advantage be taken of the conditioning treatment and of the careful machining of the face.



For their dimensional stability, strength, ease of machining and gluing, redwood frames are also widely used



Redwood cores after application of cross bands and face veneers

Machining End and Side Grain.

It is advisable to machine the end grain of the finished panel before machining the side grain. This will reduce the possibility of chipping at the corners. Satisfactory end grain cuts may be made by any of the following methods:

Jointer at 3,600 rpm.

Circular cross cut saw with 8 points per inch or circular hollow ground novelty saw with 6 points and raker at 3,600 rpm.

Spindle shaper; 2 knives in collars with 45° included angle from 5,400 to 7,200 rpm. Single spiral cutter at 5,400 rpm.

However, the best results have been obtained with the spindle shaper. With this machine, operated as noted above on Clear All Heart vertical grain redwood, no tear outs resulted and only 4.4% of the pieces showed any degree of roughness.

Shaping the side grain offers little problem, if any. The machining practices of the side grain will usually be

dictated by what the cross bands and face veneers will stand rather than by the redwood core.

SUMMARY

Redwood has more desirable qualities for furniture cores than any other commercial American wood. It will be continuously available in the form of Shop grade, and to a lesser extent in more highly refined forms. Satisfactory results in the fabricating of redwood into furniture cores and the building of the cores into furniture are dependent only on good machining and gluing practices and do not require special equipment or techniques.



Perfect stability of the redwood cores enhances the value of fine craftsmanship

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CALIFORNIA

Redwood

ASSOCIATION

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THE GLUING OF CALIFORNIA REDWOOD

The use of glue joints in the fabrication of wood products is a major factor in the conservation of forest resources. Nearly every product of glued wood construction has advantages over the same product produced from one piece of wood. More complete utilization is effected through the use of smaller pieces with resulting economies. Glued constructions usually have better dimensional stability and higher strength than single piece constructions and frequently entail less machining and waste.

THE GLUE JOINT

Wood, because of its cellular structure, can be glued more readily than most other materials, such as glass, plastics and metals. In general, the lighter the weight of the wood the easier it will glue. The glue does not penetrate the cell walls, but only fills the cell cavities, or pores of the wood. There are five links in the chain that make a good glue joint between two pieces.

1. The glue-to-wood surface bond on the first piece.
2. The glue anchored in the cell cavities of the first piece.
3. The glue between the wood surfaces.
4. The glue anchored in the cell cavities of the second piece.
5. The glue-to-wood surface bond on the second piece.

Since the success or failure of a glue joint depends on the strength of each of these links, they will be referred to again.

THE WOOD

Properties of Redwood. California Redwood has been classified by the U. S. Forest Products Laboratory as one of the woods that glue easily under a wide range of gluing conditions. In addition, the heartwood and sapwood have been found to take and hold glue equally well. The Laboratory's classifications are:

- Group I. Woods that glue easily under a wide range of gluing conditions.
- Group II. Woods that glue satisfactorily with different glues and with moderate care in the gluing operation.
- Group III. Woods that glue satisfactorily providing carefully controlled gluing conditions are used.

Group IV. Woods that require special treatment before gluing to obtain the best results.

Both the heartwood and sapwood of redwood are classed in Group I.

In addition to the ease with which it may be glued, redwood has several characteristics which give it wide application in glued-up products. It has a low shrinkage factor; the lowest volumetric shrinkage of any commercial American species. This means that it will "stay put" and hold its dimensions for long periods of time, under a wide range of moisture conditions.

Redwood is relatively easy to work, with either machine or hand tools. This is important since good machining of the surface is essential in preparation for gluing, and most products are worked or machined after gluing. Good paint retention and natural durability of the heartwood are other advantages which are often important.

PREPARATION OF THE WOOD BEFORE GLUING

Seasoning. The moisture content of the wood before gluing should be such that, when increased by whatever moisture is added by the glue, it will be as near as practicable to the average moisture content of the article in use. The average moisture content of interior woodwork is about 7% for the United States. It ranges from 4% in the Northern states in winter and in the desert states in summer to 13% along the coasts in summer. Exterior woodwork will have about 12% average moisture content.

The amount of moisture added by the glue in various types of construction is shown in Table I. From these figures, it may be assumed that the moisture content of the wood, prior to gluing, for interior use, should be 5% to 7% and for exterior use, 10% to 12% for $\frac{3}{4}$ inch stock.

The stock should be uniformly dried to the desired moisture content. A maximum variation of 3% moisture content between wettest and driest pieces is acceptable. More variation than this is likely to cause trouble in the glue joint and with the final product.

If moisture content is too high, the glue which penetrates the cell cavities is diluted, curing is delayed and a weak joint results. If the moisture content is too low, the dry wood absorbs water from the glue, thickening it, preventing an even spread and preventing full penetration into the cell cavities.

Uniformity of moisture content is an important factor. If pieces of different moisture content are glued together, resulting variations in shrinkage, however small, will cause stresses in the final product. If severe, these stresses can warp or crack the piece.

Case-hardened stock should be avoided, because this can also cause warping and stress in the finished product.

Due to the need for uniform moisture content and stress-free stock, it is desirable to condition the wood just prior to machining for gluing. For small operations, not using large quantities of stock daily, this can be done by controlling the temperature and humidity of the work room, and by storing the stock, cross-piled on stickers, in the work room for several days before machining. It is desirable to hold the stock up to a week under such controlled conditions prior to using. Table II gives the various temperatures and humidities that will produce the desired equilibrium moisture content conditions.

If large quantities of stock are being used, separate conditioning chambers are desirable. In these, the proper temperature and humidity conditions can be established, and the stock, cross-piled on stickers, can be dried and conditioned to the desired moisture content and degree of uniformity. The time required will depend on the thickness and original moisture content of the stock. If air circulation can be provided around the lumber, the time of conditioning will be reduced. The higher temperatures shown in Table II will bring the wood to equilibrium conditions more rapidly than the lower temperatures.

Redwood absorbs moisture more slowly than most woods, and the changes in moisture content produce less change in dimension, but even with these desirable characteristics, the need for uniformity of moisture content at the desired level prior to gluing cannot be over-emphasized.

For fine work, mill-run stock, even though previously kiln dried, can rarely be used without some reconditioning before gluing. At least, the stock should be sampled to be sure that it is at the correct uniform moisture content before gluing.

Sorting. Different densities of wood have different shrinkage factors. While redwood is classified as a low density, or low specific gravity wood, there is considerable range in density. Some care should be observed so that ex-

extremely high density pieces are not glued to pieces of low density. The differences in shrinkage, however slight, will put a stress on the joint which may lead to distortion and even failure of the product. The only care that need be taken here is to see that the extremely light, low specific gravity pieces are laid out and glued together. The same applies to the extremely high density pieces. The great bulk of the stock will fall around the average and may be glued together without difficulty.

Machining. Redwood is not difficult to work, either with machine or hand tools, but good machining practices should always be followed. These include proper sharpening and jointing of the knives, proper machine set-up and proper feed speeds to give the desired number of knife-marks per inch. The details of surfacing and sawing are covered in data sheet 2A2-2 "The Machining of California Redwood" published by the California Redwood Association. The details of machining across the grain, as in end-grain cuts, are covered by "Shaping the End Grain of Redwood for Core Stock" published by the U. S. Forest Products Laboratory, Report No. R1755, January, 1950.

Some points, applying particularly to machining prior to gluing, require special attention. The mating surfaces should be as uniform as possible, so that wood to wood contact can be obtained over a high percentage of the area. Normally, a planer is used for surfacing the face, and a jointer is used for the edges. If so, the practices outlined in "The Machining of California Redwood" should be followed. The surface should be smooth without distinct knife marks. Distinct wave marks will prevent good contact, cause a thick and thin glue line, and result in a weak joint. On the other hand, a burnished surface, such as results from dull knives, is not desirable. This type of surface is not readily wetted by the glue, and incomplete glue coverage results. Ten to fourteen knife marks per inch, made by sharp, well-jointed knives, give a satisfactory surface.

A sawn surface is frequently used for cores and for certain industrial uses. This is satisfactory, if made with a smooth cutting saw. The surface should be very even and solid without loose splinters and torn grain.

The mating surfaces should be checked frequently; once an hour is best on a continuous operation, to be sure they are correct. One method of checking is to lay the two surfaces together and to inspect them visually for full contact. Then turn both pieces over, and finally turn just one piece over. In

all possible positions, full contact should show without high spots or ridges.

Storage Time From Machining to Gluing. The time interval between machining and gluing should be as short as possible. The advantages of preconditioning and fine machining may be partly lost if machined stock is allowed to accumulate ahead of the glue operation. This is particularly true if the stock is held in rooms without temperature and humidity control.

TYPES OF CONSTRUCTION

All of the various forms of assembly, common in glued construction, are used with redwood, but some are much more generally used than others.

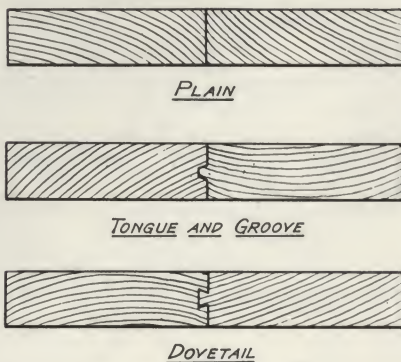


Figure 1.

Edge-glued. The parallel grain construction of edge gluing is one of the most frequently used joints in redwood. The plain joint of Figure 1A is becoming widely used, particularly with electronic gluing methods. Good jointing or sawing prior to gluing is essential. If one or both edges are not square, the glue line will not be of uniform thickness and a weak joint will result.

The other joints of Figure 1 also require careful machining to give good wood-to-wood contact. The joint shown in Figure 1, the dove-tail, has been frequently used, particularly for room-temperature-setting glues.

Face-glued. The parallel grain construction of face-gluing, commonly called laminating, is used in building up large sections for such work as structural members and blanks for foundry patterns. The surfaces are usually prepared on a planer. The principal precautions here are to get a good surface with sharp knives and proper number of knife marks per inch, and to be sure that boards are not warped.

Cross-banded. Face-gluing is also involved when cross bands and face veneers of redwood are glued to a redwood core or when hardwood veneers are glued to a redwood core. It also applies in the manufacture of redwood plywood. Good surfaces are essential in this construction as in the one previously mentioned. Slight imperfections in the machining of the core are particularly significant. Not only do they weaken the glue joint, but they may show through the cross-bands and mar the face veneers.

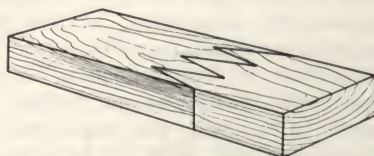
End-glued. Whenever one or both of the mating surfaces are end-grained, the problems of end-gluing or butt joints should be considered. Normally, end joints are not made with square-edged surfaces because the strength of such a joint would be low. For gluing end-grain to end-grain, the scarf makes a simple, strong joint. A slope of at least one in eight should be used, and one in twelve is more desirable. This joint requires the simplest machining



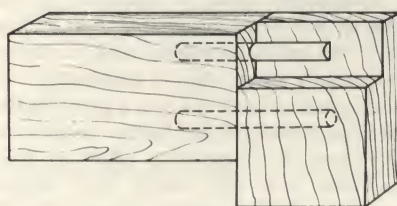
High frequency gluing of redwood in a custom millwork plant.



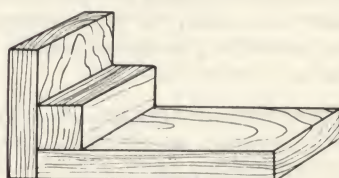
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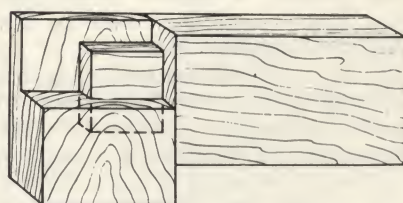
SERRATE OR FINGER



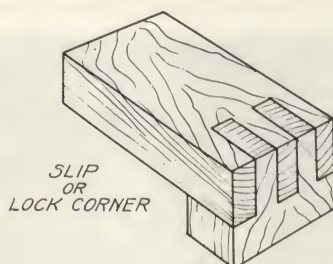
DOWEL



BLOCKED



MORTISE AND TENON



SLIP
OR
LOCK CORNER



TONGUE AND GROOVE



End and edge glued redwood cores to be used in drawing boards and drafting tables.

operations, but it is wasteful of stock. In production quantities, the finger-joint or the "Z" joint are usually used to conserve material.

One common joint involving the gluing of end grain to side grain is used in applying a veneer to the end grain surface of a redwood furniture core. Other than by this application, end grain is rarely glued to side grain without reinforcing the joint. Common methods of reinforcing these joints are mortising and doweeling. By these, and other types illustrated in Figure 2, adequately strong end-grain joints may be made. All machining must be accurate to obtain maximum strength.

THE GLUE

Selection. While the durability of redwood makes it desirable for products that will be exposed to the weather, or other severe exposure, its texture, color and grain give redwood many interior uses under mild conditions. This versatility results in almost all types of glue being used in fabricating redwood.

Table III lists the most common wood-working glues used at present and gives the properties and characteristics that will assist in selecting the proper glue for a particular use.

There is only one caution in selecting a glue for redwood. Some glues stain redwood on either side of the glue joint. For certain industrial uses and for the preparation of cores which will later be faced, this is no problem; but in all uses where the glue line is visible in the finished product, and where discoloration would be undesirable, these glues should be avoided. The glues which stain redwood are casein, vegetable starch and soy bean. The animal glues and synthetic resins will not stain.

Even though redwood has a very low shrinkage factor, special considera-

tion should be given to designing glue joints that will be alternately wet and dry. The first consideration is to select a waterproof glue. Table III gives ratings of the various glues in this respect. The second point is that a larger number of thin plies will exert less stress on the glue line than will a few thick plies.

Storage. It is best to store glue in the manufacturer's container where it will be properly protected from moisture and kept free from contamination. Different glues have varying lengths of storage life, as indicated in Table III. They should be stored carefully at the temperature recommended by the manufacturer and not held in excess of the recommended time.

Particular attention should be given to keeping the glue dry. If it should become lumpy in storage, so that it does not mix easily to a smooth paste, it should be discarded.

Mixing. Measuring the ingredients by weight is the most accurate method. It is often easier and faster to measure the ingredients by volume. If this is done, the measured amounts should be checked frequently by weighing in order to obtain good control. The manufacturer's instructions for mixing should be followed carefully. Particular care should be taken to avoid extenders which are not specifically recommended for the glue and gluing equipment. This is extremely important in high-frequency gluing where indiscriminate additions may encourage arcing and burning. The same precautions apply to the additions of salt to the glue mix. It is recommended that these additions be made only upon the advice of the glue manufacturers.

The amount of water and/or other solvents used in the initial mix should

Figure 2.

**TABLE I—Calculated¹ Percentages of Moisture Added to Wood in Gluing
With Room-Temperature-Setting Glues**

Number of plies or laminations	Species and thickness of plies or laminations	MOISTURE ADDED WITH GLUE ²	
		Casein glue	Urea-resin glue
3	1/8-inch core, 1/16-inch faces, redwood	Percent 16.8	Percent 5.6
3	1/4-inch core, 1/16-inch faces, redwood.	11.5	3.8
5	All plies 1/8-inch, redwood.	13.7	4.6
5	3/4-inch core, 1/16-inch crossbands, redwood; 1/20- inch faces, yellow birch.	8.5	2.9
5	3/4-inch core, 1/20-inch crossbands, redwood; 1/32- inch faces, yellow birch.	9.7	3.1
8	All laminations 3/4-inch, redwood.	2.6	.9

¹ Based on oven-dry weight of wood and dry glue in panels. In the calculations it is assumed that none of the glue is lost by squeeze-out.

² Assumed spreads of 75 pounds of casein glue and 45 pounds of urea-resin glue per 1,000 square feet of glue-joint area. It is also assumed the casein glue contained 66.7 percent water and the urea-resin glue contained 37.5 percent water. Specific gravity values, (oven-dry weight and volume) were assumed to be 0.66 for yellow birch and 0.42 for redwood.

be carefully weighed as noted above. For different types of joints, it is sometimes necessary to vary the amount of liquid. In redwood, there is not sufficient difference in porosity between flat and vertical grain to warrant a different mix for these surfaces. End grain is more porous and requires a higher glue-to-water ratio.

Once the glue has been mixed, it should be used within the working life noted in Table III. If the glue should thicken before being used, it should be discarded. It should not be thinned by adding more solvent.

THE GLUING OPERATION

Temperature and Humidity Control. It is essential that the gluing operations be carried on under controlled conditions of temperature and humidity.

Best results are obtained when the glue and the wood, before spreading, are at equilibrium with the atmosphere of the glue room. The temperature should be between 70° and 80°F. and the relative humidity between 30% and 40%. If low temperatures are allowed in the glue room a longer curing time will be required, since most glues set faster at higher temperature. If too high a temperature is used, the glue will set during the open assembly time and a weak joint will result. A low humidity will result in excessive drying and stressing of the wood surface and rapid loss of moisture from the glue and the open assembly time should be reduced. High humidity will retard the drying of the glue joint.

In bringing the wood to the temperature of the glue room, a minimum of one hour per 1/4" of thickness should be allowed. This will insure the wood

reaching equilibrium with the room temperature.

Glue Spreading. An adequate uniform spread of glue is essential. If some areas of the surface receive insufficient glue, the strength of the joint will be reduced. If too much glue is used, it will either result in excessive squeeze-out and waste or it will form a thick glue line which is lower in strength and durability than one of normal thickness. If not enough glue is used, penetration into the cell cavities will result in a non-continuous film of glue and a weak joint will result.

According to the type of operation and the volume being handled, the glue may be spread in a variety of ways—brush, gun, spray, serrated roller or mechanical spreader. Roll spreaders are the most accurate. They can be regulated easily to apply a uniform film of the proper thickness; once regulated, they will deliver that film with a minimum of attention.

To determine the amount of spread, pieces of measurable glue surface area can be weighed before and after glue application. From this, the glue spread in pounds per thousand square feet can be calculated and compared with Table III. If it is impractical to measure the glue spread by weighing, the amount of squeeze-out can be observed. A line of regularly spaced small beads of glue indicates adequate spread. An observation of the glue squeeze-out should be continued during production. In high frequency edge-gluing, the electrodes will flatten the beads to a band, but experience in observation will assist in determining the adequacy of the glue spread.

Generally, glue is applied to only one of the mating surfaces. For vertical and flat grain surfaces, well-machined or smooth sawn, this is adequate. On end-grain cuts where more penetration into the wood occurs, better results are obtained by applying glue to both surfaces. For this work, the recommended glue quantities, from Table III, are increased by 25% and half of the total amount is spread on each surface. Double spreading is also desirable when assembly periods approach the maximum permissible.

Assembly Periods. A fundamental principle in obtaining consistently high quality joints with any glue is that the glue in the joint should be at a certain optimum consistency at the time pressure is applied to the joint. The proper consistency may be considerably different from that of the glue mix at the time of spreading, and although this consistency cannot be readily determined directly, the principle must be kept in mind in considering the inter-relationship of the amount of spread, assembly conditions, and the amount of pressure applied. Application of pressure too early with a thin



Short pieces, with finger joint, ready for end gluing.

TABLE II—Temperature and Humidity Relations for Various Equilibrium Moisture Contents

Dry Bulb Temp., °F.	Relative Humidity, Percent					
	60	50	40	30	20	10
	Equilibrium Moisture Content of Wood, Percent					
60	11.1	9.5	7.8	6.3	4.7	2.5
70	10.9	9.2	7.7	6.2	4.5	2.4
80	10.7	9.1	7.5	6.0	4.5	2.2
90	10.5	9.0	7.4	5.9	4.3	2.3
100	10.3	8.7	7.2	5.7	4.0	2.4
110	9.9	8.4	6.8	5.4	4.0	2.3
120	9.7	8.1	6.6	5.4	3.9	2.3
130	9.4	7.8	6.4	5.0	3.7	2.0
140	9.0	7.5	6.0	4.8	3.5	.....
150	8.6	7.2	5.7	4.5	3.2	.....
160	8.2	6.8	5.4	4.2	3.0	.....

glue will result in excessive squeeze-out and starved joints; whereas excessive delay in application of pressure will result in dry, or precured joints which will not bond properly to the other wood surface. Permissible ranges of assembly periods with each type of glue are given in Table III. Satisfactory glue joints should be obtained within any of the ranges shown, providing the remainder of the gluing conditions are suitable.

In using room-temperature-setting glues, it is necessary that the assembly time be relatively short, as indicated in Table III, so that the glue is fluid when pressure is applied to the joint. This will allow the transfer of glue to both surfaces and permit the formation of a thin, uniform film of glue. Assembly periods for room-temperature-setting glues generally should be shortened as the wood temperature increases (except for animal glue), or where the glue spread is thinner. When hot animal glue is used at 90°F. or so, the longer assembly period shown in Table III is generally necessary for the same glue mixture; whereas, when the wood temperature is lower, the assembly period should be shorter. In the use of hot-press glues, as in veneering to redwood cores, the assembly time can usually be much longer than for the room-temperature-setting glue. The heat of the press causes many glues to flow, although they may have dried to a tack-free condition during the assembly period.

Like the amount of spread, the assembly period will affect the glue line thickness. Thus, if the finished glue line shows proper squeeze-out, both adequate spread and assembly conditions are indicated.

Pressure. Joints must be placed under pressure after assembling in order to bring the redwood surfaces close together to form a film of glue which is continuous and even in thickness. The gluing pressure should not be excessive, because it might crush and weaken the wood or squeeze too much glue from the joint. The pressure should not be less than a certain minimum, otherwise thick, uneven glue lines will result, and such joints will be weak. A pressure of 100 to 150 pounds per square inch is generally adequate for redwood. If the pieces in the assembly are rather thick and of large area, the

higher pressure is usually applied, but if the pieces are thin and pliable, the lower pressure is generally sufficient. Data for calculating the pressure applied are listed in Table IV.

Curing or Setting the Glue.

The conditions for curing the glue may vary considerably depending on the type of glue used, and on the design and service requirements of the glued joint. Broad requirements are listed in Table III. Joints which are expected to be subject to rather severe mechanical stresses due to moisture content changes, or to other service conditions, will require a more complete initial cure under more extensive curing conditions than would a joint of light construction not likely to be subjected to appreciable stressing. The manufacturer of the glue generally furnishes directions for curing the glue for different types of joints and at various temperatures.

It should be noted that animal, starch, casein, and polyvinyl-resin-emulsion glues develop strength or set largely by drying or loss of water to the wood or the air. Casein glues, to some extent, and all the thermosetting resin glues, urea, resorcinol, phenol and melamine, develop strength by undergoing chemical curing reactions. These, like all chemical reactions, are accelerated by heating. Advantage of this fact is often taken to shorten pressure periods with these resin glues by heating the glue line with high frequency, steam, infrared, or electric strip heaters. It should be noted that since wood conducts heat to the glue slowly, the actual glue line temperature, which determines the speed of curing, may be considerably



Dimensional stability and good gluing properties are essential for fine millwork, such as these architectural columns.

TABLE III.—PROPERTIES AND USE CHARACTERISTICS OF SOME

TYPE OF GLUE	PRINCIPAL USE	COLOR OF GLUE LINE	STORAGE LIFE AT 80° F. ¹	WORKING LIFE AT 75° F.
			<i>Months</i>	<i>Hours</i>
ANIMAL ⁵ (bone, hide; heated or prepared liquid)	Interior furniture	Almost colorless	Indefinite (long)	Indefinite (long)
STARCH (heated or prepared liquid)	Interior furniture, doors	Light to dark brown ⁷	Indefinite (long)	Indefinite (long)
SOYBEAN	Interior plywood	Light to dark brown ⁷	Indefinite (long)	8
CASEIN	Interior plywood furniture, doors, laminated rafters	Light to dark brown ⁷	Indefinite (long)	4 to 5
POLYVINYL-RESIN EMULSION	Interior furniture (assembly joints)	Colorless	Indefinite (long)	Indefinite (long)
UREA RESIN Room-temperature	Interior plywood and laminated members	Colorless to light tan	12 (powder)	2 to 8
Hot-press		Colorless to light tan	1 (liquid)	8
MELAMINE RESIN	Exterior plywood	Colorless to light tan	12	36
MELAMINE-UREA RESIN	Exterior plywood	Colorless to light tan	12	8
PHENOL RESIN Acid-catalyzed	Exterior doors	Light to dark red	1	8
Alkali-catalyzed	Exterior plywood	Dark red	1	8
RESORCINOL RESIN	Exterior doors, exterior laminated or edge-glued products	Dark red	6 to 12	2½ to 4

¹Based on general information from glue manufacturers and general experience rather than on extensive comparative tests. Other data are based on experimental results. Glues with short ranges of assembly time and temperature require more careful scheduling between application and curing than those glues with wide ranges.

²Under normal conditions of temperature and relative humidity, such as exist in interiors of occupied buildings, all these glues possess adequate durability.

³Generally the wood should be at 70° F. or higher when glue is applied.

⁴Based largely on tests made at room temperature after continuous exposure at 158° F. and 20 percent relative humidity for several months. Unless otherwise noted each type of glue retained adequate strength when stressed at temperatures up to 160° F.

⁵Information given is for a ground glue the equivalent of No. 12 in the National Association of Glue Manufacturers' grades (first three lines under "Usual Procedures in Gluing Redwood" are for a water to glue ratio of 2¼ to 1, the fourth for a 3 to 1 ratio).

lower than the temperature on the wood surface. This dependence on temperature also explains why decreasing the glue line temperature below 70°F. slows the rate of cure so much that an adequate cure is not obtained. The principal advantage of high-frequency heating over other conventional methods of curing glues with heat is that the former method can be made to introduce the heat directly

into the glue line without dissipating it to the wood.

Edge-glued joints made in clamp carriers with animal, starch, or casein glue are usually taken out of the clamps in about 1 hour, although they should then be allowed to condition further for the development of greater joint strength, and to allow the moisture from the glue to distribute before machining of the piece. Edge-glued joints made with resin glues may also

be pressed in clamp carriers but are often cured by high-frequency dielectric heating, which provides enough joint strength in ½ to 1 minute to permit removal from pressure, although full joint strength is not yet developed. Care should be observed to avoid the use of excessive power in curing such joints by high frequency as this is a common cause of arcing with resultant charring of the wood.

Veneered panels and laminated

THE TYPES OF GLUE THAT MAY BE USED IN GLUING REDWOOD

USUAL PROCEDURES IN GLUING REDWOOD ¹					DURABILITY OF JOINTS ²	
AMOUNT OF GLUE SPREAD	ASSEMBLY TIME RANGES AT 70° to 90° F.		SETTING OR CURING REQUIREMENTS		IN WATER OR AT HIGH HUMIDITY	AT HIGH TEMPERATURES ⁴
	OPEN	CLOSED	TEMPERATURE ³	TIME		
<i>Lbs. per 1000 sq. ft.</i>	<i>Minutes</i>	<i>Minutes</i>	<i>°F.</i>			
60 to 65	0 to ½	0 to 1	70	1 to 2 hr.	Low ⁶	Fair
65 to 70	½ to 2½	1 to 5	80			
70 to 75	1½ to 10	3 to 20	90			
70 to 75	2½ to 10	5 to 20	90			
60 to 80	0 to 12	0 to 25	70 to 90	1 to 24 hr.	Low ⁶	Fair
60 to 80	0 to 10	0 to 20	70 to 90	24 hr.	Low ⁸	Good
60 to 80	0 to 10	0 to 20	70 to 90	1 to 24 hr.	Low ⁸	Good
40 to 50	0 to 10	0 to 20	70 to 90	½ to 1 hr.	Low ⁶	Fair ⁹
40 to 50	0 to 10	0 to 20	70 to 90	¹⁰ 4 to 24 hr.	Good ⁸	Fair
35 to 45	0 to 30	0 to 240	240 to 260	¹⁰ 5 to 10 min.	Good ⁸	Fair
35 to 45	0 to 30	0 to 24 (hr.)	240 to 260	¹⁰ 5 to 10 min.	Excellent	Excellent
35 to 45	0 to 30	0 to 240	240 to 260	¹⁰ 5 to 10 min.	Good	Good
40 to 50	0 to 20	0 to 60	75 to 110	¹⁰ 24 hr.	Excellent	Fair to good
35 to 45	0 to 30	0 to 24 (hr.)	280 to 300	¹⁰ 6 to 10 min.	Excellent	Excellent
40 to 50	¹¹ 0 to 10	¹¹ 0 to 120	70 to 90	¹⁰ 4 to 8 hr.	Excellent	Excellent

⁶In an atmosphere in which wood will not attain a moisture content over 16 percent, durability is good to excellent.

⁷Although the glue itself may be rather light in color, alkali in this glue may stain redwood at the glue line, producing dark red or brown glue lines. Special casein glues are said to cause less staining.

⁸In an atmosphere in which wood will not attain a moisture content over 20 percent, durability is good to excellent.

⁹It was found that some of the better glues of this type adequately withstood stressing at 160° F. while others were not adequate at 110° F.

¹⁰The indicated curing periods may be shortened by using higher curing temperatures or by raising glue line temperatures more rapidly, as with high frequency heating.

¹¹For critical applications some minimum assembly may be desirable.

joints cured at room temperature generally require clamping periods of 4 to 24 hours, but for thermosetting-resin glues the curing period may be reduced if the glued member is heated to temperature of from 120° to 180°F.

Drying and Conditioning of Glue Joints. After gluing, the moisture in the glued assembly is unevenly distributed. It is naturally concentrated at the glue line. To prevent sunken joints or subsequent distortion of the as-

sembly, some conditioning before machining is generally advisable.

The moisture content of the entire assembly of edge joints or lumber laminations is not increased very much in gluing, but the moisture content at the glue line is probably very high. The wood adjacent to the joint is in an expanded condition, and if the joint is surfaced at this time, a depression along the glue line will result when the wood dries and shrinks. The presence

of this depression may be observed, even though the joint is subsequently covered with veneer, particularly if the veneered panel is finished with a high polish. Edge-glued joints, or products with thick laminations to be finished with a highly reflecting finish without subsequent veneering, should be piled on stickers for 7 days at 80°F. and 30 percent relative humidity for conditioning after gluing. For lumber cores, in which the edge joints will sub-



The slender lines of modern furniture call for a wood easy to work and easy to glue.

sequently be covered with veneers, it is expected that these periods may be reduced, perhaps by one-half.

Veneer plywood or lumber-core panels made with glues cured at room temperature often contain excess moisture which should be removed before further fabrication. For interior use, this plywood should finally contain only about 7 percent moisture, and for exterior use, about 12 percent. When the panels contain thick lumber cores and the glue adds very little water to the panel, the plywood can be piled solidly and allowed to condition at room temperature for several days. A better practice, which evaporates more of the moisture through the faces, is the use of panel kilns at about 110°F. in which the panels are stickered and can be dried in about 24 hours. When plywood is hot-pressed, the panels frequently are too dry when they come from the press, and water must be added. This may be done in conditioning rooms or by passing the panels through a water spray or between rolls wet with water. After water is added by spray or rolls, the panels should be stacked solidly until the moisture is distributed evenly throughout the panels.

INSPECTION AND QUALITY CONTROL.

With the proper application of the gluing methods described in this data sheet, glue joints of good quality should result. It is essential, however, that constant control and inspection be maintained along the line of production.

Control of Gluing Conditions.

Equipment and material must be in condition to provide good gluing conditions. Some of the points of inspection are:

Saws and Planer Knives.

Although the machining of redwood results in slower wearing of cutting edges than some other species, these cutting surfaces must be kept sharp, and the bearings and arbors of planers and saws should be kept in good working condition. Frequent inspection of gluing surfaces should be made to be certain these surfaces are clean and as smooth and even as possible. Bowed or twisted boards for edge-gluing should be culled in this operation as they may cause trouble in obtaining uniformly

well-fitted joints, particularly in newer high speed presses using high-frequency heating.

Drying and Conditioning Equipment. The moisture content of redwood going into production should be determined frequently by sampling or with a moisture meter. This will allow prompt change of the drying procedure, with subsequent saving of labor and material, if the moisture content of the stock happens to be outside the range desired for the particular gluing operation.

Pressure Devices. Such equipment as clamps, "I" beams, turnbuckles, platens, and cauls should be examined periodically to make certain that they are clean and free of deformation which might cause variation in pressure on the assembly being glued. Pressure indicators should be calibrated at regular intervals. Presses should also be checked during the curing period to be certain that the desired pressure is maintained.

Shop and Press Temperatures.

Shop temperatures should be determined frequently so that gluing conditions, particularly assembly time, may be altered accordingly, and to insure that the required minimum cure temperature can be maintained during cold press operations. The temperature of the platens of a hot press may be determined with thermocouples and potentiometer. The press should be kept in such condition that the temperature is uniform throughout the platens. The temperature of the lumber at the time of gluing is also important, particularly with hot animal glues.

TABLE IV—Data on Screw Clamps and Other Pressure Devices Used in Gluing

Equipment tested	Force applied	Length of lever arm	Pitch of screw	Diameter of screw	Total load	Coefficient of friction
	<i>Pounds</i>	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>	<i>Pounds</i>	
Jackscrew	170.0	37	1/3	1-5/16	33,850	0.1978
Jackscrew	170.0	18	1/3	1-5/16	16,350	.1997
Jackscrew	170.0	31	1/2	2-5/16	16,720	.2000
Jackscrew	140.0	7	1/8	7/8	7,500	.2498
C-clamp	70.0	1-3/4	1/8	9/16	1,585	.20
C-clamp	69.5	3	1/8	9/16	2,700	.20
C-clamp	70.2	2	1/5	11/16	1,370	.20
Bar clamp	79.9	2 1/2	1/8	1/2	2,810	.20
Wood clamp	71.3	1/2	1/14	3/8	720	.20

CONTROL OF PRODUCTS

Proper control of production must include the inspection of glue joints. Such inspection certainly should be made if there is any question about the adequacy of any of the gluing conditions. It is also good practice to examine glue joints periodically, even though all gluing conditions are apparently satisfactory.

Glue joints may be examined without destroying the assembly, or more suitably, by breaking sample glue joints from trimmings, waste material, or from an actual production assembly (this latter as a last resort if the joints appear faulty). A joint may be broken open for examination by placing a chisel, preferably blunt, at the glue line and striking it with a hammer. Plywood may be examined by inserting a knife blade at the glue line and stripping off the veneers. When a properly broken joint shows a high percentage of deep wood failure and little or no failure in the glue, it may be concluded that the gluing conditions were satisfactory. If, however, the break shows a

high percentage of failure in the glue with low percentage of fuzzy or shallow wood failure, or a smooth surface with no glue at all, then the gluing conditions must be reviewed in order to determine the cause of the poor joint. The following outline will aid in finding the cause of low joint quality when the appearance of the surfaces of the broken joint has been observed.

Starved Joint. This may occur in joints even though an adequate amount of glue was originally applied. The surfaces of the broken joint are dull and there appears to be little or no glue in the joint. This may be due to one of the following conditions, or a combination of them:

Excessively high moisture content in the wood.

Glue spread too light or uneven.
Glue too thin.

Wood temperature too high (animal glue).

Assembly time too short.

Gluing pressure too great.

A starved joint may also result from inadequate glue spread due to foamy glue resulting from excessive paddle speed in mixing the glue or from excessive agitation on a mechanical spreader.

Chilled Joint. This type of joint usually is characterized by uneven thickness of the glue on one surface of the broken joint, with irregular glossy areas, and little or no glue on the other surface. It occurs chiefly with animal glue, and is due to congealing of the glue from cooling on the wood before adequate pressure has been applied to the joint. Following are the causes:

Wood temperature too low.

Assembly time too long.

Dried Joint. This type of joint is similar in appearance to the chilled joint, but may occur with any type of glue. Usually one surface has little or no glue apparent, while the other has a thick glue film which may be uneven.



Light weight and strong glue joints are the important factors in these luggage frames of redwood.



Redwood cores, used in the finest furniture, insure freedom from warping and distortion of the highly polished surfaces.

Often spreader or brush marks are visible in the glue. The cause:

Assembly time too long.

Lack of contact over part of joint area because of improper machining, dimensional changes after machining, or non-uniform gluing pressures.

Blistered Joint (in plywood).

Loose areas occur between adjacent plies in plywood otherwise well bonded. The condition may or may not be indicated by a raised area in the face of the panel. It is found most frequently in hot-press plywood. Causes may be:

Moisture content of veneers too high.
Too high percentage of water in glue.

Assembly period too short.

Too short a press cycle at the elevated temperature.

Precured Joints (in hot-press plywood). One surface of the broken joint may have glossy areas and uneven film of glue. The glue was partially cured by contact of the coated veneer with a hot surface before the plies were brought together by the gluing pressure. The cause:

Press was loaded and closed too slowly.

Use of hot cauls that should have been cooled before re-use.

APPENDIX

Explanation of Terms Used in Gluing. Those who are familiar with gluing may require no explanation of the terms used, but for the benefit of those who are about to enter the field, some explanations are desirable.

Moisture Content of the Wood.

The amount of moisture in the wood is expressed as a percentage of the

oven-dry weight of the wood. The moisture content of wood may be determined by a moisture meter or by weighing a sample of the wood before and after drying to constant weight in an oven at 215°F. The latter method is the more accurate, but a meter is useful as a rapid means of finding the moisture content.

The following formula is used to find the moisture content by the oven-drying method:

$$M = \frac{W_1 - W_0}{W_0} \times 100$$

in which M = percent moisture content, W_1 = weight of wood before drying, and W_0 = weight of wood after drying.

Glue Spread. The amount of glue applied to the surfaces to be joined. It is usually expressed in pounds of glue mix per 1,000 square feet of glue joint area, sometimes in grams per square foot of glue joint area, not area of panel. The expression is often abbreviated to pounds per 1,000 square foot of glue line. The glue is *single spread* if applied to only one of the surfaces to be joined, and *double spread* if applied to both surfaces.

Assembly Time. This refers to the interval of time between application of the glue to the surfaces and the application of pressure to the assembly. It is usually the time necessary to lay up the assembly for pressing, but may



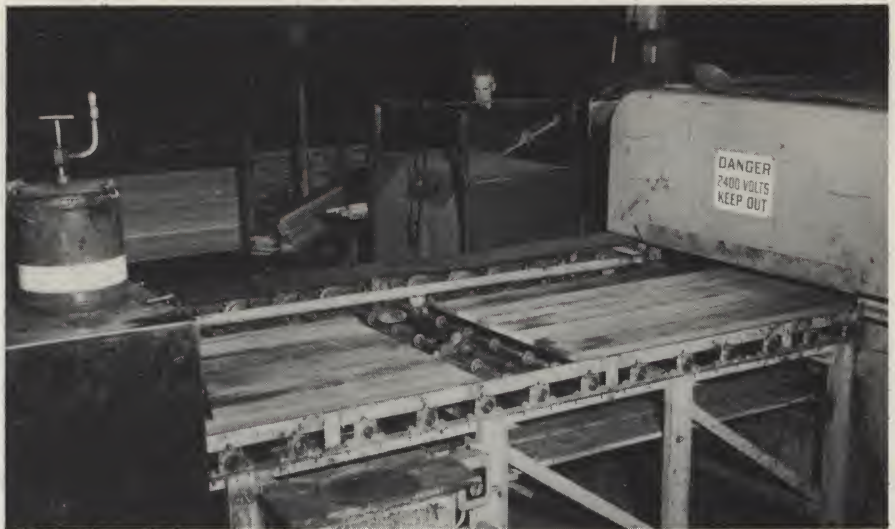
Foundry patterns, one of the most exacting jobs for which redwood is used, call for a wood that glues easily, machines well, and holds its shape through years of storage.

Appendix (Continued)

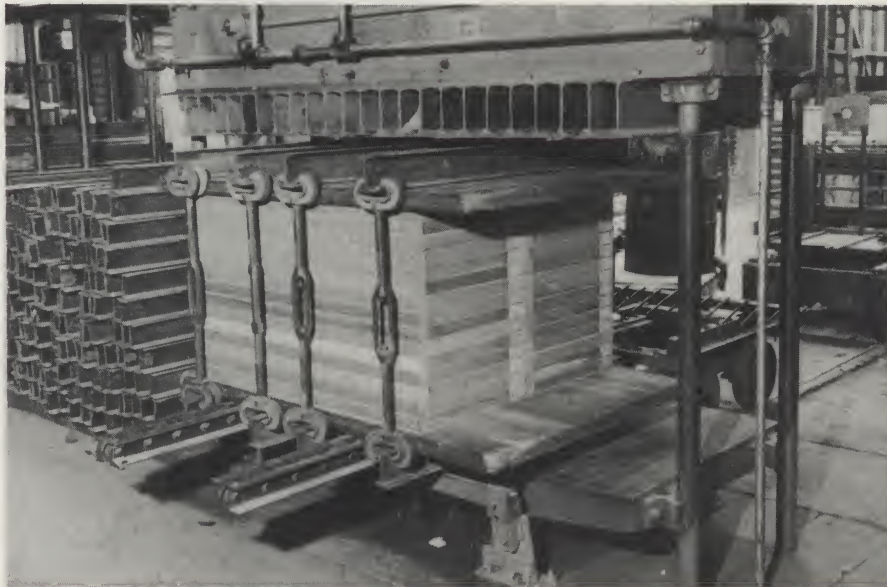
involve a deliberate or voluntary period of waiting before pressure is applied. It is termed *open assembly time* if the glue-spread surface is open to the air, or *closed assembly time* if the glue-spread surface is not in contact with the air.

Setting or Curing Conditions.

The setting or curing of the glue in the assembly is dependent on time and temperature. These factors are referred to as *curing time* and *curing temperature* and together are called *curing conditions*. The curing temperature is usually that of the glue line, which may be lower than that of the room or press during the early part of the curing



Redwood furniture cores passing through an electronic glue machine.



Pressing face veneers on redwood cores.

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ACKNOWLEDGMENT

Much of the information on which this data sheet is based was developed in a cooperative project with the United States Forest Products Laboratory at Madison, Wisconsin.

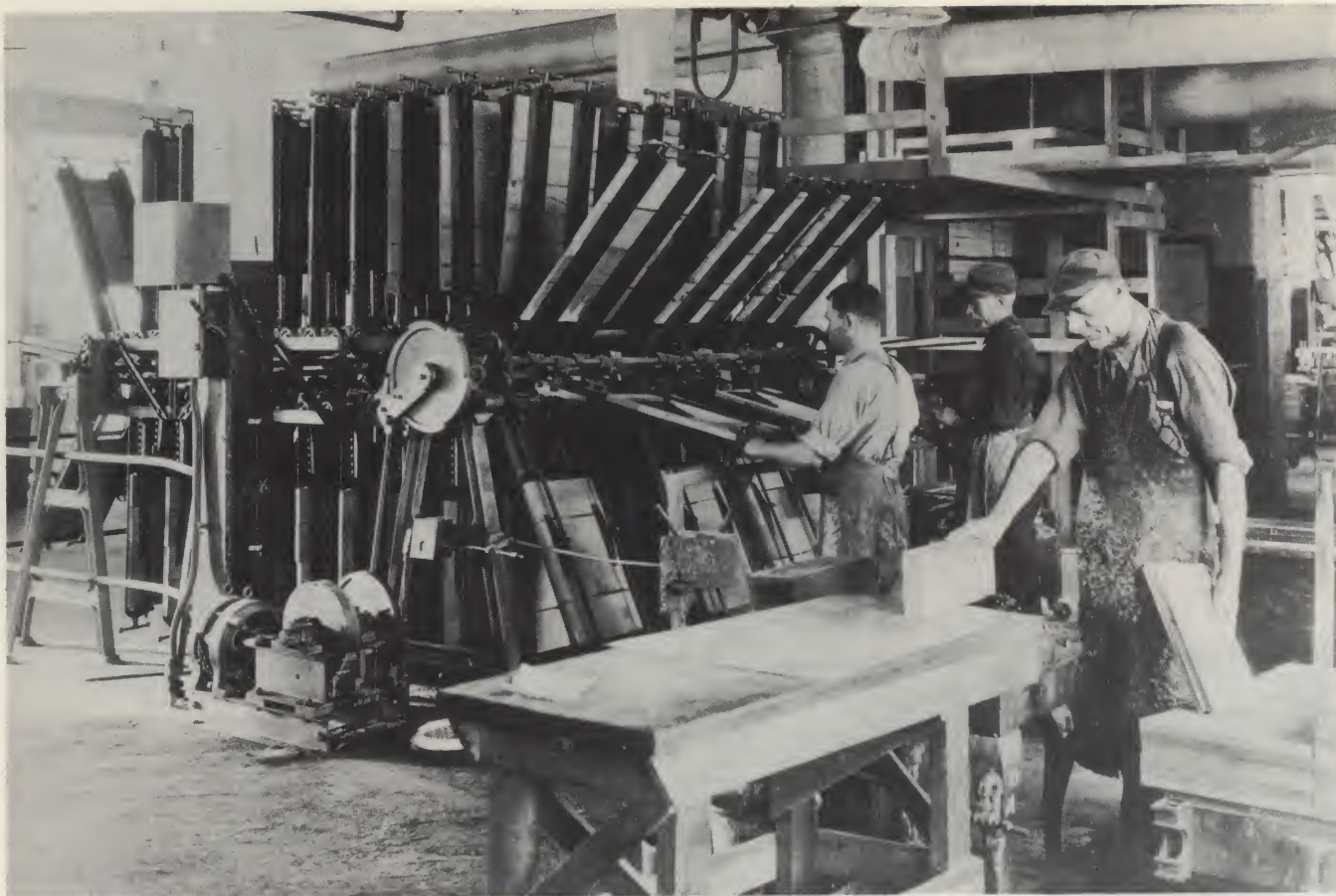
period because of slow transfer of heat through wood.

Storage Life of Glues. This is the period during which the ingredients of a glue remain suitable for use before mixing. It is a matter of months for some glues, and years for other glues. It is usually shorter as the temperature of storage increases and usually shorter as moisture conditions of storage increase.

Working Life of the Glue. This is the period during which the glue remains usable after the ingredients are combined. It is dependent principally on the temperature of the glue and is sometimes termed "pot life." Many glues, particularly the resins, become jelled at the end of the working life.



Glue laminating produces a stronger and more stable timber than one cut from a single piece.



Clamp carriers are widely used in the gluing of redwood, particularly where production volumes do not warrant the use of electronic equipment.

CHECK LIST FOR THE GLUER OF REDWOOD

Following are 10 points to be checked during the gluing procedure:

1. Are all members of the assembly at the proper moisture content and temperature?
All pieces in a core should preferably be of one species, of similar specific gravity, and should not vary more than 3 percent in moisture content from each other.
2. Are the gluing surfaces as smooth, flat, free of distortion, and as even as possible? If it is an assembly joint, is the fit proper?
3. Has the glue been selected to give joints of suitable properties?
Adequate initial strength and resistance to deterioration under expected service.
4. Has the glue been stored and mixed properly?
Do not use overaged glue. Do not thin down glue that has thickened in aging.
5. Is the wood and the room at the proper temperature for gluing?
6. Is the glue being spread evenly and in proper amount? Is there a uniform line of glue beads at each edge of the joints after pressure is applied?
7. Have all joints been placed under pressure within the prescribed range of assembly conditions known to give good joints?
8. Is the pressure on the assembly adequate, evenly distributed, and continuously maintained?
9. Has the assembly been under pressure long enough and at the proper temperature for the glue joint to attain adequate strength before releasing pressure?
10. Has the glued assembly been properly conditioned before machining or further fabrication?

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THE MACHINING OF CALIFORNIA REDWOOD

I. INTRODUCTION

The increasing use of redwood for a wide variety of applications throughout the country has indicated the need for a concise listing of the practices which should be observed to insure satisfactory machining results. The following data represents the advice of the most experienced personnel in the field and are presented as a guide for the use of men throughout the lumber industry who are concerned with the surfacing and remanufacturing of California redwood.

The three principal objectives of machining which have been considered are:

1. To obtain a maximum quality of surface.
2. To maintain maximum control over dimension.
3. To accomplish the desired results with as few operations and as low a cost as possible.

The operations which are most frequently performed are:

1. Surfacing
2. Resawing
3. Trimming
4. Sanding

In each operation, three factors have an influence on the quality and cost of the work:

1. The individual characteristics of the particular machine.
2. The care which is used in setting up and operating the machine.
3. The characteristics of the particular lumber species being handled which make it more or less susceptible to damage from improper practices.

These factors will be considered separately under each of the machining operations.

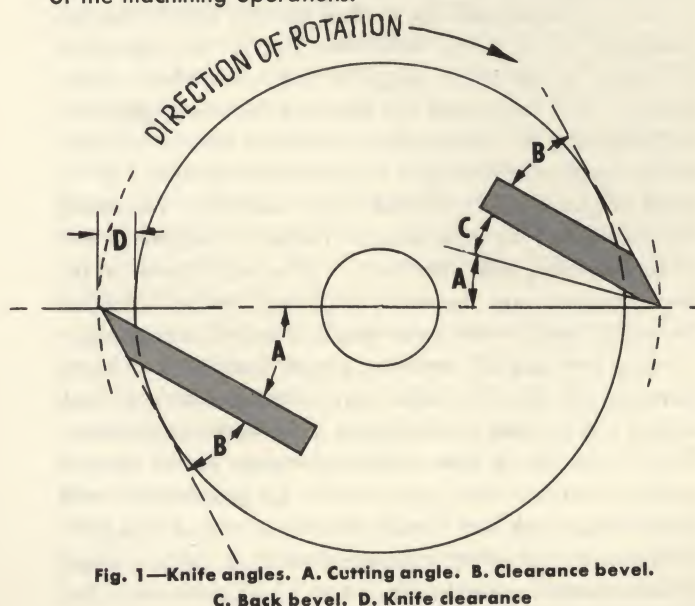


Fig. 1—Knife angles. A. Cutting angle. B. Clearance bevel. C. Back bevel. D. Knife clearance

II. SURFACING

The Machine. Due to the many types of machines in common use and the fact that the particular machine available may have to be used regardless of its exact suitability, there is little that can be said about the machine other than to

point out the need for having it in alignment and in first class operating condition. The following points particularly should be observed:

1. Proper alignment of rolls with bed plate.
2. Proper alignment of heads with bed plate.
3. Proper balance of the heads.

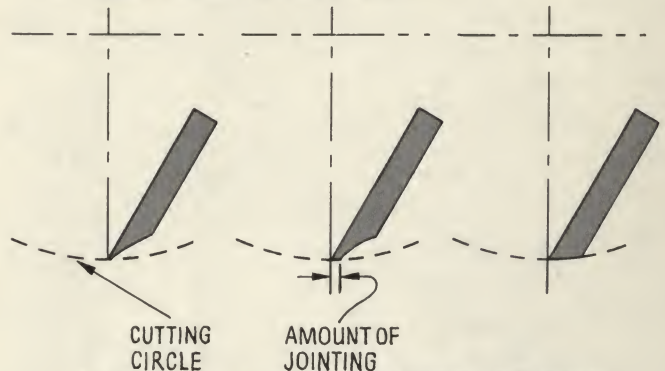


Fig. 2—Effect of jointing. Unjointed knife (left), proper jointing (center), excessive jointing (right)

Use of the Machine

Cutting Angle. The most frequently used cutting angles are 20 degrees on dry lumber and 30 degrees on green lumber. The cutting angle is illustrated in Fig. 1. Grinding a back bevel on the knives can be used to decrease the cutting angle if necessary to bring the angle in line with the above recommendations. The back bevel need not be used for any reason other than to produce a proper cutting angle.

Clearance Bevel. This angle is not as important as the cutting angle, but it should be as small as possible to permit more frequent jointing without developing too wide a heel. If the angle is too small, the cutting edge of the knife will be too weak and knife breakage may occur. A clearance bevel of approximately 30 degrees is recommended.

Knife Clearance. Due to the variety of head designs in use, it is not possible to specify the knife clearance exactly. Clearance is important, however, in providing free room for chips until they can be removed by the blower. Failure to provide sufficient clearance will result in chip marks on the lumber. A clearance of $3/16"$ to $1/4"$ is recommended as shown in Fig. 1.

Jointing. The effect of jointing is to bring the cutting edges of all of the knives into a perfect circle. Jointing should be done often and lightly until a heel approximately $1/32"$ wide is developed. Running with a wider heel may produce raised grain due to insufficient cutting action and the pressure of the heel on the board surface. The effect of jointing is illustrated in Fig. 2. Knives may be expected to run longest without jointing on dry wood, and the shortest time on partially dry or rain wet lumber. Knives will wear faster on green lumber than on dry, but not so rapidly as on partially dry stock. Heavy jointing at one time should be avoided because of the feather edge it may leave on the knives. The feather edge tends to hold chips on the knives, causing chip mark. The effect of the feather edge may be



Fig. 5—Satisfactory surfacing, flat grain

reduced by moving the jointing stone back and forth over the knives after the last cut has been made until no further sparks are produced.

Chip Breaker. The chip breaker should be set as close to the cutting circle as possible to reduce the possibility of torn or chipped grain. The breaker should be set within a $\frac{1}{2}$ " of the knives for best results.

Pressure Bar. The pressure on the bar should be closely watched, as excessive pressure may cause raised grain.

Rolls. Pressure on the rolls should be controlled to prevent crushing which may result in raised grain. The pull-out roll should not be used when the machine is in steady operation due to the danger of sniping the ends of the boards.

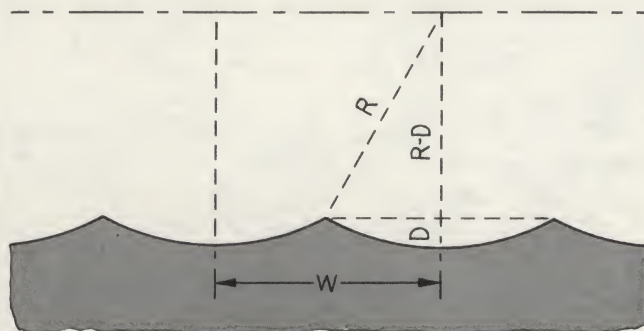


Fig. 3—Knife marks. R. Radius of cutting circle. W. Distance between knife marks. D. Wave height

Feed Speed. Knife Marks Per Inch and Depth of Cut Per Knife. The rate of feed is one of the most easily controlled factors affecting the quality of the work, and it is one of the factors having the most influence on the quality. The feed is usually controlled to produce the desired knife marks per inch, but in so doing the depth of cut of individual knives is affected and this is what actually affects the appearance of the work. Reference Fig. 3. "D" represents the depth of cut or the height of the wave marks on the lumber. "W" represents the distance between successive knife cuts and "R" represents the radius of the cutting circle. For a smooth surfacing job, it is desirable to keep "D" as small as possible. "D" may be made smaller by decreasing the feed speed, by increasing the radius of the cutting circle or by increasing either the number of knives or speed of the head. In most cases, the only one of these factors which can be varied easily is the feed speed. It has been found that varying the feed in accordance with Table I to produce between 10 and 12 knife marks per inch on dry finish lumber will produce a satisfactory wave depth and surface. Fig. 5 and Fig. 6 show effect of planer knives on well surfaced flat and edge grain lumber. On green lumber and dry exterior work 8 to 9 marks per inch may be found satisfactory. On extremely crossed grained or curly grained wood it may be necessary to go to 15 or more marks per inch to prevent torn or broken grain.

Particular Characteristics of Redwood

Growth Rings. There is considerable difference between the density of the hard summerwood of the annual growth ring and the soft springwood. The hard summerwood

tends to resist the cutting action of the knives more than does the soft springwood. In true vertical grain pieces this condition does not produce any noticeable problem, as the wood does not compress unevenly under the rolls or knives. In pieces in which the grain is not truly vertical, and particularly in true slash grain boards, this difference in density may cause some difficulty unless proper precautions are taken. The greatest difference in density, and weakest point in the annual ring, occurs where the springwood of one ring touches the summerwood of the previous ring. It is possible, by pressure, to cause the rings to separate at this line. On the heart side of slash grain pieces (that side of the board lying nearest the heart of the tree, see Fig. 4) the hard summerwood overlaps the soft springwood of the next annual ring, and this point of overlap is the weakest point.

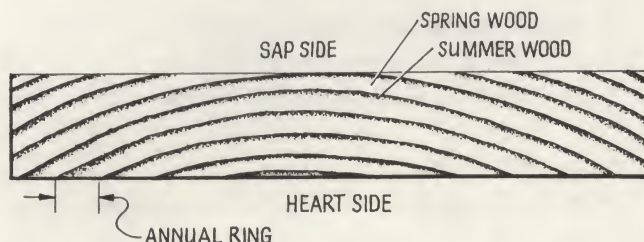


Fig. 4—Cross section, slash grain board

When the pressure from the rolls or knives is applied, the summerwood is pressed down into the springwood, and in severe cases, a compression fracture of the springwood results. When the pressure is released, and particularly if the surface of the piece loses moisture after surfacing, the summerwood will tend to raise above the surface of the board and produce the condition commonly called raised grain. On the sap side of the board, the hard summerwood overlays the soft springwood of the same annual ring. This line of overlap between the summerwood and springwood of the same annual ring has not a weak point, and therefore separation does not occur. *The pattern or face of the board should always be run on the sap side.* Pieces should be turned over if necessary as they are fed into the machine in order to have the face on the sap side.

Moisture Content. Redwood can be satisfactorily surfaced green from the saw or when thoroughly dry if the various recommendations as to knife angle, jointing, etc., are observed. The machining of redwood when partially dry or surface wet is extremely difficult and should be avoided when possible.

Grain Angle. Redwood boards are normally straight grained and show little tendency to chip grain. Some boards, however, particularly slash grained pieces from the butt logs, have cross grain. Some logs produce curly grained wood. These pieces are prized for interior paneling because of their figure, but they require special care in surfacing to prevent chipping the grain. On cross grained pieces, the knives should cut with the grain on the face and the face should be on the sap side.



Fig. 6—Satisfactory surfacing, vertical grain



Fig. 7—Raised grain. (Photograph specially lighted and enlarged to emphasize defects)

On pieces of curly grain, it may be found desirable to increase the number of knife cuts per inch to 15 or more. Experimenting on a board or two will usually enable the operator to determine the proper rate of feed.

Specific Problems and Their Correction

Raised Grain. (Fig. 7) Raised grain is usually caused by one of the following:

1. Running the pattern or face side of the board on the heart rather than the sap side of the board.
2. Too much pressure on the pressure bar.
3. Feed rolls too tight.
4. Dull knives.
5. Improper cutting angle, particularly too small a cutting angle resulting from too much back bevel.
6. Too wide a heel on the knives resulting from excessive jointing.
7. Partially dry lumber or surface moisture on dry lumber. Allowing moisture to get on surfaced lumber.
8. Too slow a feed resulting in too many knife marks per inch.
9. Too light a cut.

Torn or Chipped Grain. (Fig. 8) Torn or chipped grain is usually caused by one of the following:

1. Cross grained lumber, particularly if the knife cuts are made against the grain.
2. Chip breaker too far from the knives.
3. Too high a feed speed, resulting in too deep a wave height and too few knife marks per inch. In this connection, it should be noted from Fig. 3 that a large diameter head, even though it produces the same number of knife marks per inch, will give a lower wave height than a smaller head. The cut will not be as steep and the chipping not as severe as with a smaller head. In general, chipping may be eliminated by slowing down the machine and correcting the other points mentioned.

Fuzzy Grain. This defect rarely appears in redwood. It may appear when surfacing partially dry lumber or dry lumber which has been allowed to re-absorb surface moisture from rain or fog.

Machine Burn. (Fig. 9) Machine burn marks show distinctly on redwood. It is important to maintain a continuous feed speed and not stop lumber in the machine. The jointed heel should be kept at a minimum, preferably $1/32$ " or less to avoid burning. While knife burns are probably more common than roller burns, the latter will occur if lumber is stopped in the machine.

Chip Mark. (Fig. 10) Chip marks show distinctly on the surface of redwood boards, particularly if they appear on the boards of softer texture, because they appear in a lighter color than the unmarked surface. Chip marks may be caused by any of the following:

1. Inadequate air suction, including plugged or partially plugged blower system. Any small obstruction in the blower lines may reduce the air flow and cause the chips to be thrown back on the head. Improper fit of hoods over the heads may reduce the effective air pressure.



Fig. 8—Chipped grain. (Photograph specially lighted and enlarged to emphasize defects)



Fig. 9—Machine burn. (Photograph specially lighted and enlarged to emphasize defects)

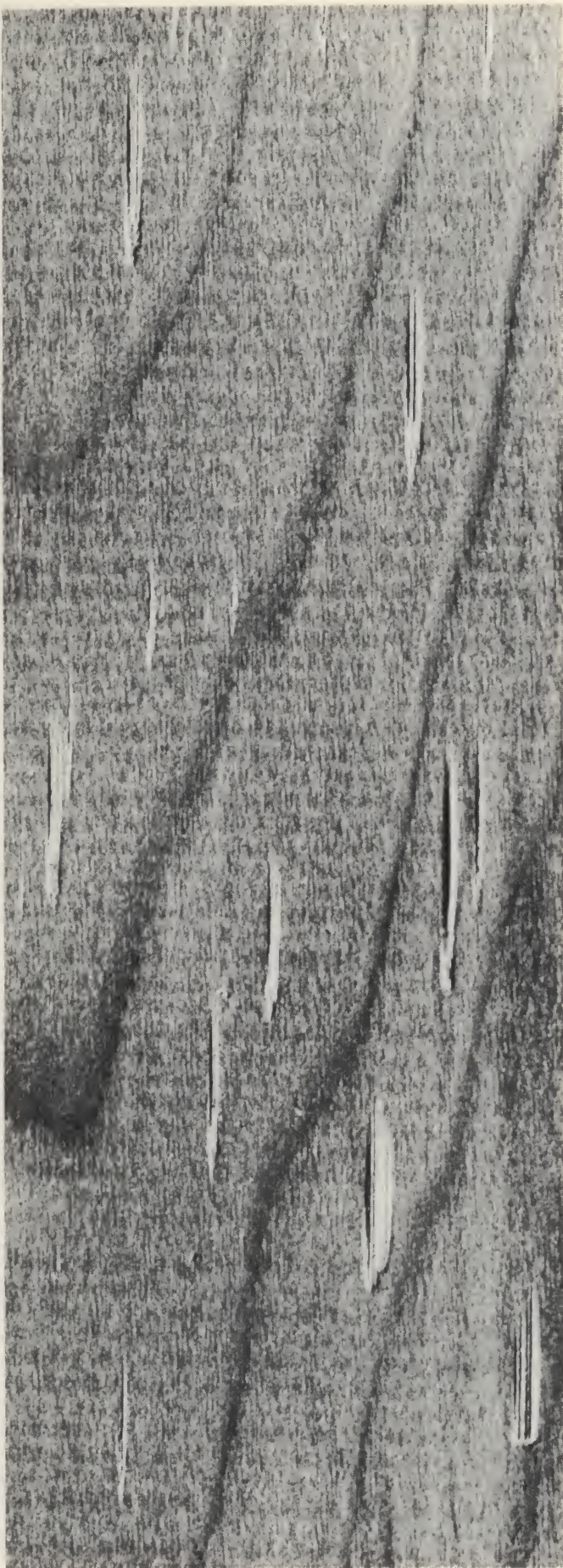


Fig. 10—Chip mark. (Photograph specially lighted and enlarged to emphasize defects)

2. Insufficient throat room between the head and the cutting circle. This may be increased by increasing the knife clearance as shown in Fig. 1.

3. Newly jointed knives, particularly if the jointing has been heavy and the feather edge left on the knives.

4. Dull knives.

5. Partially seasoned lumber or surface wet lumber, in which cases the chips tend to stick to the knives more readily than either thoroughly wet or dry shavings.

Sniping. This condition can occur on either the sides or faces of the board, and may be caused by conditions of the machine or of the lumber. With regard to the machine, particular attention should be given to alignment of bed, rolls and head and to inspection of both pressure bar and bed plates for uneven worn spots. The condition of the lumber may cause sniping by putting uneven pressure on the individual pieces. If a piece over-size in width follows a piece of normal width, the side pressure will be taken from the normal board, and sniping on the edges may occur. If a piece over-size in thickness follows a piece of normal thickness, top and bottom pressure will be reduced on the normal board and sniping of the faces may occur. Crooked lumber may produce snipes on either face or edges for the same reasons.

Revolution Wave Marks. In addition to the individual knife marks which result from normal surfacing, revolution wave marks are sometimes developed. This wave has the high points spaced by the distance the board travels during one or more full revolutions of the head. This condition is caused by one or more of the following:

1. Knives, gibs, screws or cylinder out of balance.
2. Poor, worn or loose bearings.
3. Motors either electrically or dynamically out of balance in the case of motorized machines.

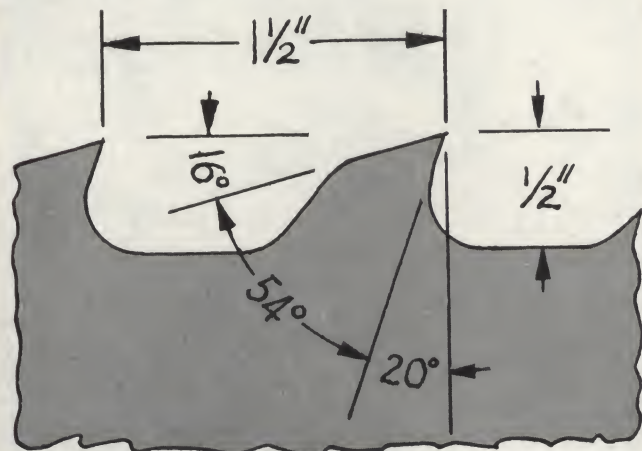


Fig. 11—Tooth form, dry resawing

III. RESAWING

The Machine. Satisfactory work is done on dry lumber with machines having rim speeds of 7200 to 8500 feet per minute. The lower speed of 7200 feet per minute is easier to work with and is generally recommended unless continuous operation and volume production indicate the use of the higher speeds. The accepted speeds on green lumber range from 7500 to 8500 feet per minute, with a recommended speed of 8200 feet per minute.

TABLE I—KNIFE CUTS PER INCH 3600 RPM SPINDLE SPEED

Feed, Lineal Feet Per Minute	NUMBER OF KNIVES PER HEAD										
	1	2	4	6	8	10	12	14	16	18	20
10.....	30.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
15.....	20.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20.....	15.0	30.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
25.....	12.0	24.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
30.....	10.0	20.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
35.....	8.6	17.1	.....	.....	.....	.....	.....	.....	.....	.....	.....
40.....	7.5	15.0	30.0	.....	.....	.....	.....	.....	.....	.....	.....
45.....	6.7	13.3	26.6	.....	.....	.....	.....	.....	.....	.....	.....
50.....	6.0	12.0	24.0	.....	.....	.....	.....	.....	.....	.....	.....
60.....	5.0	10.0	20.0	30.0	.....	.....	.....	.....	.....	.....	.....
70.....	.....	8.6	17.1	25.7	.....	.....	.....	.....	.....	.....	.....
80.....	.....	7.5	15.0	22.5	30.0	.....	.....	.....	.....	.....	.....
90.....	.....	6.7	13.3	20.0	26.6	.....	.....	.....	.....	.....	.....
100.....	.....	6.0	12.0	18.0	24.0	30.0	.....	.....	.....	.....	.....
120.....	.....	5.0	10.0	15.0	20.0	25.0	30.0	.....	.....	.....	.....
140.....	.....	.....	8.6	12.8	17.1	21.4	25.6	30.0	.....	.....	.....
160.....	.....	.....	7.5	11.3	15.0	18.7	22.5	26.2	30.0	.....	.....
180.....	.....	.....	6.7	10.0	13.3	16.6	20.0	23.3	26.6	30.0	.....
200.....	.....	.....	6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0
220.....	.....	.....	5.5	8.2	10.9	13.6	16.4	19.1	21.8	24.6	27.2
240.....	.....	.....	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.4	25.0
260.....	.....	.....	.....	6.9	9.2	11.5	13.8	16.1	18.4	20.8	23.1
280.....	.....	.....	.....	6.4	8.6	10.8	12.8	15.0	17.1	19.3	21.4
300.....	.....	.....	.....	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
325.....	.....	.....	.....	5.5	7.4	9.2	11.1	12.9	14.8	16.6	18.5
350.....	.....	.....	.....	5.1	6.9	8.6	10.3	12.0	13.7	15.4	17.1
375.....	.....	.....	.....	.....	6.4	8.0	9.6	11.2	12.8	14.4	16.0
400.....	.....	.....	.....	.....	6.0	7.5	9.0	10.5	12.0	13.5	15.0
425.....	.....	.....	.....	.....	5.6	7.0	8.5	9.9	11.3	12.7	14.1
450.....	.....	.....	.....	.....	5.3	6.7	8.0	9.3	10.7	12.0	13.3
475.....	.....	.....	.....	.....	.....	6.3	7.6	8.8	10.1	11.4	12.6
500.....	.....	.....	.....	.....	.....	6.0	7.2	8.4	9.6	10.8	12.0
550.....	.....	.....	.....	.....	.....	5.4	6.5	7.6	8.7	9.8	10.8
600.....	.....	.....	.....	.....	.....	5.0	6.0	7.0	8.0	9.0	10.0
650.....	.....	.....	.....	.....	.....	.....	5.5	6.5	7.4	8.3	9.2
700.....	.....	.....	.....	.....	.....	.....	5.1	6.0	6.9	7.7	8.6
750.....	.....	.....	.....	.....	.....	.....	.....	5.6	6.4	7.2	8.0
800.....	.....	.....	.....	.....	.....	.....	.....	5.3	6.0	6.8	7.5
900.....	.....	.....	.....	.....	.....	.....	.....	.....	5.3	6.0	6.7
1000.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.4	6.0
1100.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5.4

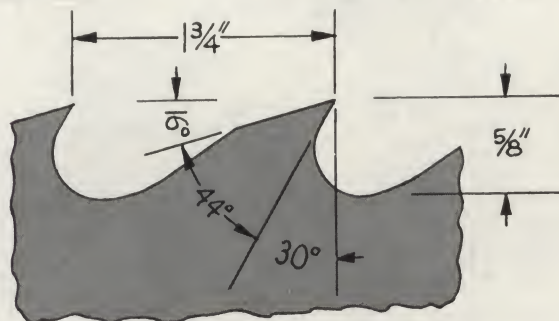


Fig. 12—Tooth form, green resawing

Use of the Machine. Fig. 11 shows the tooth form found desirable for dry lumber. If saws with the 20-degree hook are not readily available, a satisfactory job may be done with a 30-degree hook. Fig. 12 illustrates a satisfactory tooth for green lumber.

Feed Speed. The most satisfactory feed speed with the specified tooth spacing and rim speeds is 250 feet per minute maximum on dry lumber and 200 feet per minute maximum on green lumber.

IV. TRIMMING

For smooth trimming, a hollow ground saw with a rim speed of approximately 20,000 feet per minute gives excellent results. The tooth form of "Style P" saw shown in Fig. 13 has been found satisfactory.

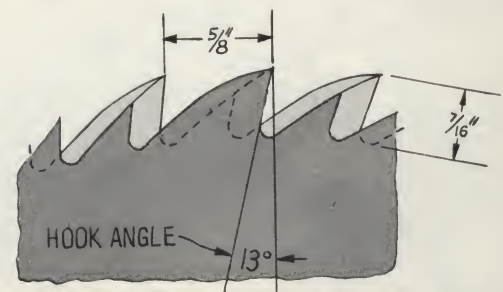
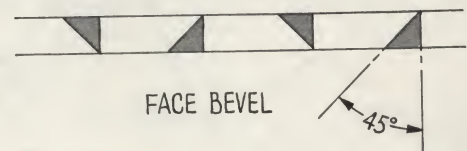


Fig. 13—Tooth form, hollow ground smooth trim saw

V. SANDING

The principal things which should be watched in regard to sanding are the coarseness of the sandpaper and the pressure which is applied to the wood during sanding. The difference in density between the summerwood and springwood will tend to show scratches, particularly on the slash grained boards, if too coarse a paper is used. If excessive pressure is used in the machine, raised grain may result. Particular attention should be paid to sanding narrow pieces, as greater pressure is exerted per square inch on these than on wider boards. In sanding wide panels, it is desirable to sand both sides to eliminate the possibility of cupping. Pieces should

be finished, at least with a prime coat, as soon after sanding as possible to reduce the possibility of the lumber absorbing moisture and developing raised grain.

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CALIFORNIA **Redwood** ASSOCIATION

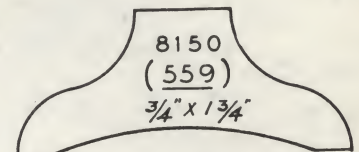
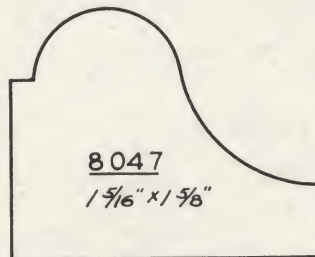
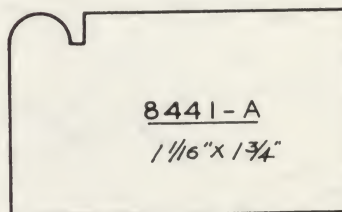
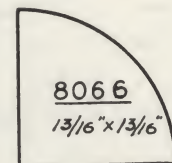
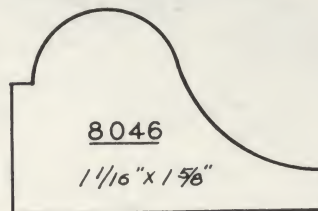
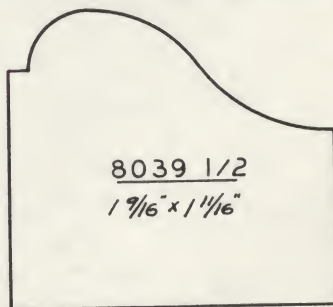
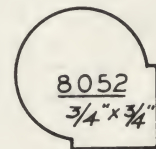
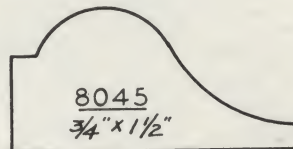
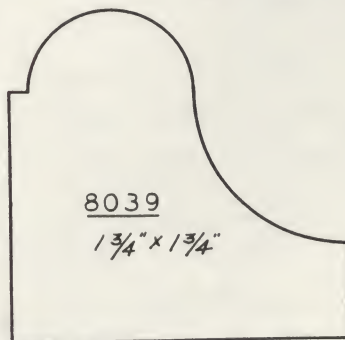
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MOULDING PATTERNS

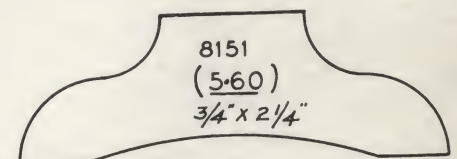
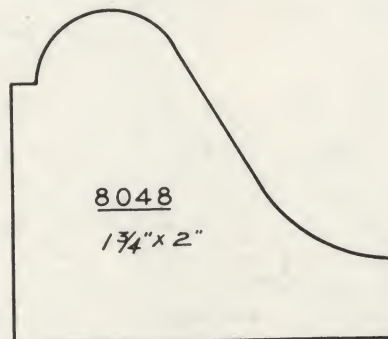
Redwood mouldings are worked to recognized standard patterns. The 8000 series, as shown in the Standard Moulding Book published by Shat-tock & McKay Company, 315 North Oakley Blvd., Chicago 12, Illinois, are the patterns most generally used.

We are reproducing herewith a few patterns which have been popular with dealers and

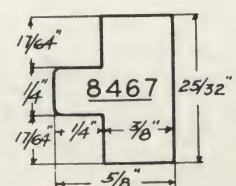
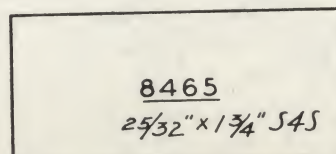
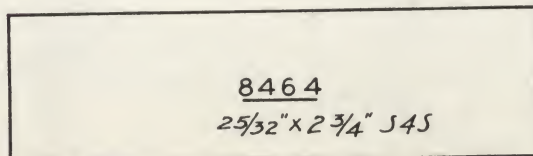
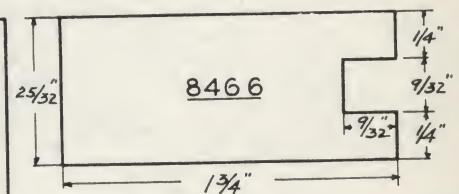
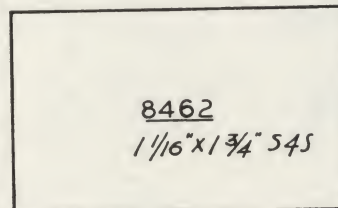
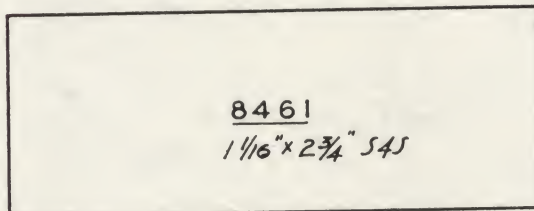
builders, but which are not included in the Standard 8000 series book referred to above. These pat-terns are illustrated to simplify specifications, orders and correspondence. By referring to "Red-wood Moulding Pattern" and the number shown on the drawing, you will specify the exact size and cross-section illustrated.



1" X 2"-O.G. BATTEN



1" X 3"-O.G. BATTEN

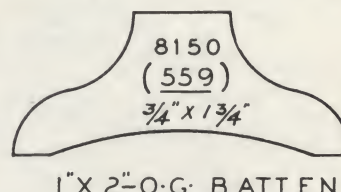
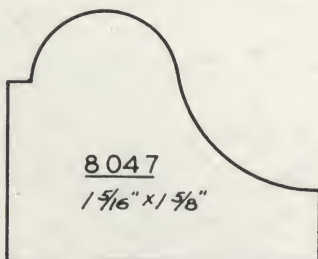
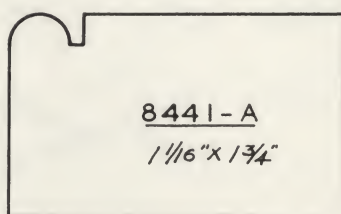
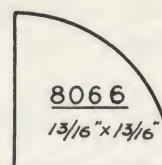
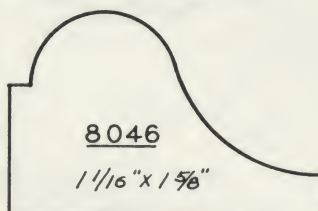
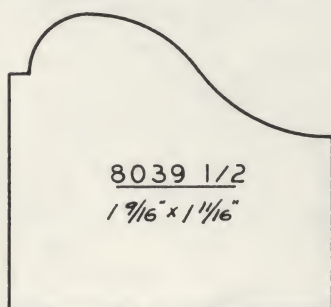
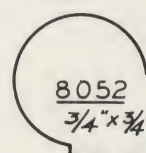
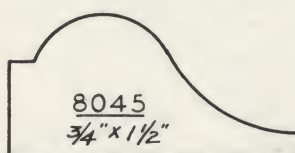
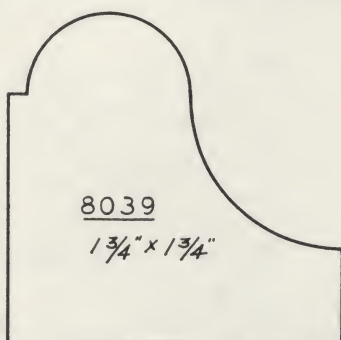


MOULDING PATTERNS

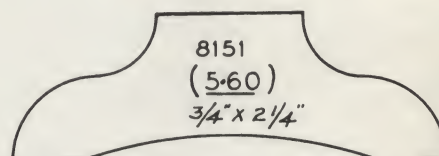
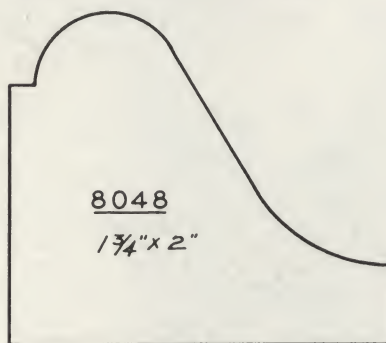
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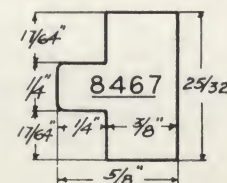
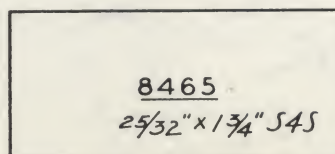
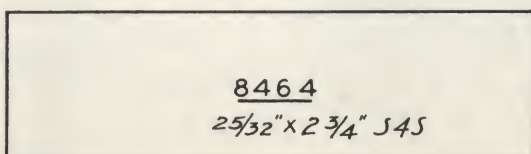
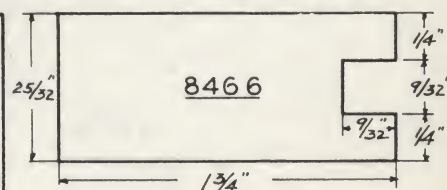
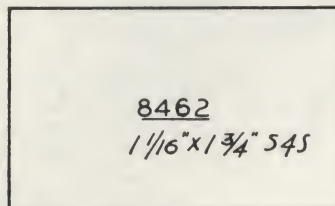
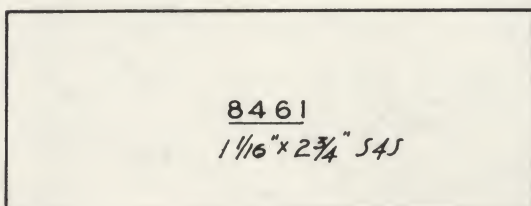
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1" X 2"-O.G. BATTEN



1" X 3"-O.G. BATTEN



INTERIOR FINISHES

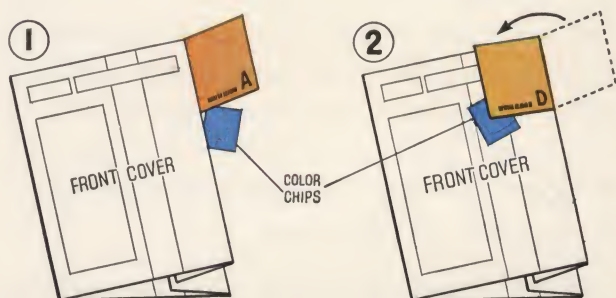
Appreciative home owners, their architects and decorators, know that no room is more luxurious than one panelled in wood. The logical, simplified design of today places much emphasis—and derives much of its decorative splendor—from the native graining and texture of various species of lumber.

DECORATIVE IMPORTANCE OF REDWOOD

Probably more than any other material, redwood has become almost synonymous with current decorative and architectural trends. In addition to its many practical qualities, its wealth of color, and the romance of the wood itself, adapt it particularly to interior uses.

In this folder are a number of suggestions, worked out in cooperation with leading manufacturers of interior finishes. Drapery and rug coordinates are suggested by Eleanor Forbes of Gump's from the world-wide selections of that famous store.

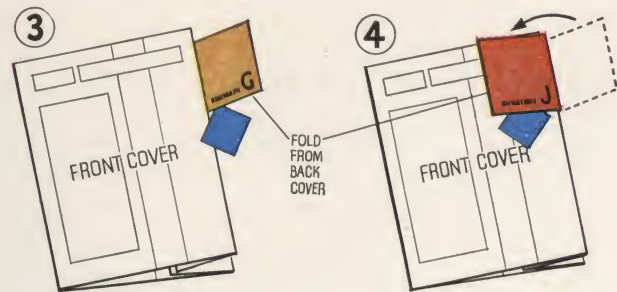
Here is a practical tool for the use of architects, decorators, and home owners in determining basic color schemes for rooms in which redwood panelling is used. All finishes illustrated can be duplicated using standard products, obtainable at any well-stocked paint store. You will find most paint dealers have duplicate copies of this folder, and directions for obtaining each of these finishes, using products which they carry in stock.



HOW TO USE THIS COLOR GUIDE

The flaps at the edge of this and the following page are *reproductions* (as close as color printing will allow) of twelve different finishes which

may be used on redwood. Notice, they are so arranged that, by folding, any one of them may be superimposed upon the drapery and rug swatches, as illustrated in the little diagrams above and below. Thus three basic elements of your room's color scheme—rugs, drapery and wall finish—can be conveniently grouped. If a painted trim is to be used, slide color chips, which your paint dealer can supply, under the flap, as illustrated.



As you accumulate actual samples of rug or drapery materials, substitute them for the reproductions shown here. You'll probably want to carry this handy folder with you when shopping for accessories.

TEST YOUR COLORS

To be sure you obtain exactly the color you wish, have your painter make up small test panels on redwood boards similar to those used for your panelling. He can make any minor variation from these standard finishes at that time. Before giving the painter final approval or placing your order for rugs and draperies, you will be wise to gather finish sample, drapery swatches, rug sample and a piece of painted trim for a final observation under both natural and artificial light.

IF ONE OF YOUR DECORATIVE ELEMENTS IS ALREADY ESTABLISHED . . .

If you already have a rug which you wish to use in your redwood room (or if upholstery or drapery color are already established), key all the remaining colors to it. In such a case, do not use the sample drape and rug colors in this folder.

NOTES ON FINISHES

The decorative value of all woods depends: first, upon the graining of the wood; secondly, upon its color; and thirdly, upon its surface texture.

Wood serves its decorative purpose best when its grain is not obscured by the finish. In fact, in most cases the choice of wood to be used within a room will depend upon the figure of its grain.

The color of the wood is capable of substantial modification, as illustrated in the reproductions shown here. Such color change may depend upon or, in some cases, determine, the whole decorative plan.

Texture of wood is also capable of modification, depending upon the type of surfacing material used. Some finishes tend to harden the surface, making it easier to maintain. Finishes are available in varying degrees of gloss.

REDWOOD GRAIN

The grain figure shown in these reproductions is typical of the range available in redwood for paneling use. All are described by the trade names "random" or "slash" grain. Redwood is also produced in vertical grain which presents little or no variation in grain pattern. (See upper portion of Sample I or lower segment of K.) Vertical grain, however, is more likely to be used for moldings and trim, rather than for paneling.

REDWOOD COLOR

The natural color of the heartwood of redwood is well represented by Sample J, although some variation in color occurs from tree to tree. The color of other sample panels shown has been modified by stains, bleaches, or pigmented fillers. All of the paint manufacturers participating in the production and distribution of this folder have products available for interior use which will retain the original color of redwood with little or no change.

Your paint dealer can give you the exact formula for obtaining each of the finishes shown. He also stocks the necessary finishing materials. Not all companies use exactly the same processes to obtain the same finish effects, due to differences in the composition of their branded products.





Essentially, however, all finishes shown here (except J) are achieved with two basic steps. First, modify the color to the extent desired, using bleaches, pigmented fillers, or stains. Secondly, apply whatever surface finish is appropriate, such as varnish, shellac, lacquer, or wax to obtain a suitable degree of hardness and gloss. It is good practice, regardless of the finish upon which you decide, to buy high quality materials from reputable dealers and follow the manufacturer's directions carefully. In addition, have the finish tested on sample boards for your approval before applying it to the wall.

NOTES ON PANELING

Remember that redwood, like other woods, is a *natural* product. There is an inherent variation in grain figure and texture. No wood presents the uniformity of appearance typical of a manufactured product. Your architect or decorator can help you put this quality to its finest decorative use. You may, for instance, find that the introduction of light-colored redwood sapwood will add a pleasantly variegated color pattern.

Panels may run either vertically or horizontally. Frequently the direction of their placement can help correct any design fault the room might have.

Width of panels can enhance the scale of the room. One of the most interesting current developments is the use of four-inch redwood tongue-and-groove, applied vertically. Many recent prize-winning homes have used redwood in this manner. It is particularly appropriate where walls continue from outdoors to indoors, through window walls.

Occasionally, wide and narrow panels can be used in combination.

Proper care should be exercised by your contractor in the handling and installation of your paneling. A Data Sheet which will help secure a satisfactory job is available without cost on request at the Redwood Association office. Ask for "Interiors: Application and Finish."

CALIFORNIA REDWOOD ASSOCIATION

576 Sacramento Street
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Following are complete specifications for matching the colors of the Redwood Panels, shown by the California Redwood Association.

FINISH "A"

- 1 coat Oil Stain mixed
 - 32 parts Driftwood Oil Stain
 - 7 parts Light Oak Oil Stain
 - 1 part Forest Green Oil Stain
- 1 coat white shellac, sanded
- 1 coat "38" Pale Trim Varnish Gloss, sanded
- 1 coat "38" Pale Trim Varnish Satin

FINISH "B"

- 2 coats Okene Preservative mixed
 - 16 parts Okene
 - 1 part Mahogany Oil Stain
- Each coat wiped with rags after setting 5 to 10 minutes.
- First coat allowed to dry 24 hours before applying the second coat.

FINISH "C"

- 1 coat Filtex (reduced 2 parts Filtex to one part turpentine)
Sandpapered when dry
- 1 coat Oil Stain mixed
 - 2 parts Dark Oak Oil Stain
 - 3 parts Light Oak Oil Stain
 - 3 parts Butternut Oil Stain
- Wiped with rags after setting 5 minutes
- 1 coat "38" Pale Trim Varnish Gloss, sandpapered
- 1 coat "38" Pale Trim Varnish Satin

FINISH "D"

- Wire brushed lightly to open grain
- Sandpaper to remove scratches
- 1 coat Paste Filler #5 White, wiped very clean.
Allow to dry over night. Sandpapered.
- 1 coat white shellac, sandpapered.
- 1 coat "38" Pale Trim Varnish Gloss, sandpapered.
- 1 coat "38" Pale Trim Varnish Satin.

FINISH "E"

- 1 Coat Oil Stain mixed
 - 4 parts Dark Oak Oil Stain
 - 1 part Forest Green Oil Stain
 - 2 parts Ash Oil Stain
- Sandpapered lightly when dry
- 1 coat white shellac, sandpapered
- 1 coat "38" Pale Trim Varnish Dull

FINISH "F"

- 1 coat Oil Stain mixed
 - 4 parts Knotty Pine Oil Stain

- 1 part Walnut Oil Stain
- 1 coat white shellac, sandpapered
- 1 coat "38" Pale Trim Varnish Gloss, sandpapered
- 1 coat "38" Pale Trim Varnish Satin

FINISH "G"

- 1 coat Early American Maple Oil Stain wiped with rags after setting 5 minutes
- 1 coat white shellac, sandpapered
- 1 coat "38" Pale Trim Varnish Gloss, sandpapered
- 1 coat "38" Pale Trim Varnish Dull

FINISH "H"

- 1 coat Ash Oil Stain
 - Wiped with rags after setting 5 minutes
 - Allowed to dry 24 hours and sandpapered
- 1 coat white shellac, sandpapered
- 1 coat "38" Pale Trim Varnish Dull

FINISH "I"

- 1 coat Oil Stain mixed
 - 8 parts Knotty Pine Oil Stain
 - 4 parts Driftwood Oil Stain
 - 1 part Walnut Oil Stain
- 1 wash coat white shellac (made with 1 part shellac, 2 parts alcohol)
- Glazed with Ash Oil Stain, wiped
- Sandpapered when dry
- 1 coat "38" Pale Trim Varnish Gloss
- 1 coat "38" Pale Trim Varnish Dull

FINISH "J"

- 1 coat Okene Preservative
 - Allow to set 5 to 10 minutes and wiped with rags
 - Allowed to dry 24 hours
- 1 coat Okene Preservative
 - Allowed to set 5 to 10 minutes and wiped with rags

FINISH "K"

- Bleached with Blanchit #1 and #2
- Sandpapered
- 2 coats Vitraloid Lacquer Dull #8843
- Sandpapered between coats

FINISH "L"

- 1 coat Oil Stain mixed
 - 8 parts Early American Maple Oil Stain
 - 1 part Light Oak Oil Stain
- 1 coat white shellac sandpapered
- 1 coat "38" Pale Trim Varnish Gloss, sandpapered
- 1 coat "38" Pale Trim Varnish Satin

